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Lecturer on Building Construction to the Regent Street Polytechnic, London
Head Master of the Polytechnic Technical School.

(MEMBER OF THE SOCIETY OF ARCHITECTS, MEMBER OF THE ARCHITECTURAL ASSOCIATION,
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PREFACE

TO THE SIXTH EDITION.

THE demand for a sixth edition has given me the opportunity of endeavouring to make this Treatise of even more use to those in practice than the preceding editions, and also to more nearly satisfy the requirements of the latest syllabuses in Building Construction of the Board of Education and other examining bodies. Many new illustrations have been added, and the text has been re-arranged and considerably enlarged.

The satisfactory reception of the preceding editions inspires the hope that this latest revision may be found still more useful not only in the United Kingdom but in all Anglo-Saxon communities. It is especially gratifying to see the book on the list of those recommended not only by the Examining Bodies in this country but also by the International Examiners of the Y. M. C. A. of New York.

In conclusion the author desires to acknowledge the valuable help he has received in this further revision and enlargement of the book by Messrs. T. H. Pritchard and A. E. Holbrow.

C. F. MITCHELL.

THE POLYTECHNIC INSTITUTE,
309, REGENT STREET, LONDON, W.
September, 1902.

PREFACE

TO THE FIFTH EDITION.

THE preparation of the fifth edition of this work, involving a considerable amount of labour, has been undertaken in the hope that it may prove even more useful than the previous issues and meet with the approval so widely accorded to them by both Teachers and Students.

Every effort has been made to further the object striven for when the first edition was prepared, viz., to supply a reliable Text-book on the principles and practice of construction for the guidance of students entering for the Examinations of the Science and Art Department and other Bodies.

Among the improvements made in the present edition may be mentioned:—

The large increase in the number of illustrations, which now reach nearly 950 (being 250 more than in the last issue) and the redrawing of almost all the originals still retained, so as to present the whole in as clear and practical a manner as possible.

The avoidance of all unnecessary dimensions on the diagrams—only such as are really *essential* to the student being included; while the names of the various parts have been carefully given.

For the first time a series of illustrations of the tools used by the excavator, bricklayer, mason, carpenter, joiner and slater have been included, and these it is hoped will be found of value.

An entirely new chapter on Building Quantities, with some general memoranda on the various trades, has been added in response to numerous requests.

Finally, the whole of the text has been carefully revised and added to, so that, although some portions have been deleted, the book is increased in size by some fifty pages.

In conclusion, I offer my sincere thanks for the valuable help accorded to me in the revision by my colleagues at the Polytechnic, whose position as specialists in the various sub-divisions of the Building trades gives a peculiar value to their services. To Mr. T. Hobart Pritchard, Trinity College, Dublin, I am indebted for help in correcting the proofs.

CHARLES F. MITCHELL.

REGENT STREET POLYTECHNIC,
LONDON, W.
September, 1900.

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CHAPTER I.

INSTRUCTIONS FOR BEGINNERS.

Instruments and Materials.—The following instructions to beginners are among those given at the Building Classes held at the Polytechnic, Regent Street, London, W.

The student should bear in mind that it is better to have a few good instruments than a greater number that are inferior, and he would find it to his advantage to buy his instruments separately from some good maker or firm, rather than purchase a complete set of inferior quality, which will be sure ultimately to prove unsatisfactory. If the instruments are required to be carried about, a good way of keeping them in order is to have a roll made of chamois or wash-leather, with separate compartments for each instrument, such as are often made in leather for pocket sets of tools.

The following instruments should be obtained:—6-inch compasses with ink and pencil points, and with double-jointed legs and round dividing points (instruments with needle points for ordinary work should be avoided), dividers, ruling pen, with one blade hinged for facilitating cleaning, and two set-squares, 45° and 60° respectively. Set-squares are made of pear-wood, celluloid and vulcanite. Those of pear-wood are not to be recommended, as the angles are subject to alteration due to the shrinkage of the wood; the celluloid are subject to warping, nevertheless are preferred by some as they are transparent, but for general work the vulcanite are undoubtedly the best, as they retain their shape, and not being transparent, there is less confusion of lines.

A set of spring bows (consisting of dividers, pen, and pencil bows) is also to be recommended for small work, though not absolutely necessary. It is better that these should not be provided with needle points, as, without abnormal care, they cannot be used for extremely fine work, as the holes get enlarged and the needles have a tendency to wobble, and the draughtsman cannot easily see if the point be placed in the exact position.

To prevent corrosion, great care should be taken to clean all instruments after they have been used.

Drawing board of yellow pine, the minimum dimensions of which should be 24 inches by 18 inches, ¾ inch thick, secured at the back with battens so arranged as to permit of the board shrinking without splitting, those with clamped ends are not to be recommended.

T-square, 24 inches long, with bevelled ebony edge, screwed on to the stock to allow the set-square to pass freely over the stock.

HB pencil for notes and sketches, H and HH pencils for drawings, india-rubber, four good drawing pins, sharp penknife, a box of colours, and glue. Cake colours are preferable for technical drawing, but the moist colours in pans are more readily mixed and are rapidly displacing the former, and the student will find it to be to his advantage to obtain these also from some good manufacturer.

A set of scales is required; as those of boxwood are expensive, their use is to a large extent replaced by sets of paper scales, such as the Polytechnic technical scales, sold by the publishers of the present work, which, having only one scale on each edge, prevent the student falling into mistakes common to the use of boxwood scales with two or more scales on each edge; the cost of the paper scales is also considerably less.

Pencil Sharpening.—A sharp penknife should be used for this purpose. For ordinary use a round point should be made, as shown in figure 1, but for drawing lines against straight-edges, especially with the harder pencils, a chisel point, as shown in figure 2, may be advantageously used, as it will retain its edge longer. Pencils in compasses should always be chisel pointed.

Drawing Paper.—The following are the sizes in general use, although the exact dimensions vary slightly with different manufacturers:—

		Inches.
Demy	Hot pressed and Not	20 by 15½
Medium	,, ,,	22 ,, 17½
Royal	Hot pressed, Not and Rough	24 ,, 19½
Imperial	,, ,, ,,	30½ ,, 22
Double Elephant	,, ,, ,,	40 ,, 26¾
Antiquarian	,, ,, ,,	52½ ,, 30½

Whatman's (*not* hot pressed) medium thickness is a quality to be recommended for finished drawings; it will stand wetting and stretching without injury, and when so treated receives shading and colouring easily and freely. Whatman's *hot-pressed* paper is useful for exhibition pen-and-ink drawings, but great

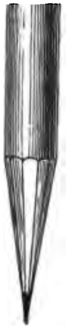


Fig. 1.

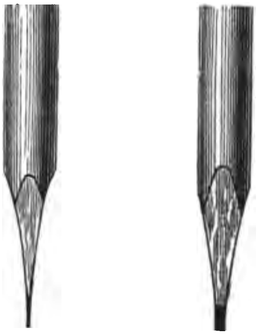


Fig. 2.

care must be exercised to prevent any mistakes, as it does not readily admit of alterations. The proper face of the paper upon which to draw is that surface on which, being held to the light, you can read the maker's name. For ordinary working drawings and details, cartridge paper, which is cheaper, or cartoon paper—of which there are many varieties, and which may be obtained up to 60 inches in width and in continuous rolls—are to be preferred.

Damp Stretching.—If the paper is to be used for a highly-finished drawing it must be very firmly attached to the board, and nothing is more suitable for the purpose than glue, or a strong paste made of flour and powdered resin. The stretched irregular edges of the paper are first cut off. The paper should then be thoroughly saturated on both faces, but if one face only is damped, it should be the upper one, as any dirt may be easily sponged off. A wide brush or clean sponge should be used, the edges of the paper being first thoroughly damped all round, and then the whole surface. The edges of the paper should not be quite as damp as the other parts of the surface. After the paper has been thoroughly damped, it must be left until the gloss entirely disappears and then turned over and placed in position on the board. Next, about three-eighths of an inch is turned up at the edge against a flat ruler or straight-edge, and a brush with glue or strong paste passed between this turned-up edge and the board; the ruler is then drawn over the prepared edge and pressed along. If the paper be found not to be thoroughly close when the ruler is removed, a paper-knife passed along the edge will remedy this. The next adjoining edge must be treated in a similar manner, then the next, and the next. When dry, the paper should present a perfectly plane surface for drawing and colouring upon. When the drawing is completed, the paper is cut with a cutting gauge or a penknife drawn along an iron straight-edge. On no account must the edge of a T-square be used for cutting against. The glued margin on the board should be carefully cleaned off with a sponge and cold water.

Centre and Datum Lines.—If the work to be produced offer any opportunity for using centre lines, draw them at the commencement as chain dotted lines. Especially should this be noted wherever window or door openings, columns, or any symmetrical details occur. These will be found of great convenience whenever any dimension is called into question, or whenever any reference or readjustment has to be made. If the drawing does not lend itself to be set out from centre lines, some important plane surfaces, such as floor levels, wall-plate levels, etc., should be drawn, and any line could be measured from the same. If, however, there be no such important surfaces or lines, which is of rare occurrence, the best thing to do is to make imaginary ones and let all measurements bear a relative position to them. These important plane surfaces or lines are known as datum surfaces or datum lines.

Section Lines.—Lines representing the traces of centre planes as shown in figure 138 should be inked in with a firm black line.

Scale Construction.—Where the dimensions of the object or detail to be drawn are too large to place conveniently on the paper, all its parts are represented reduced in some given ratio, and the drawing is said to be to scale, and the ratio of the reduction is termed the representative fraction. If the drawing is to be to an unusual scale, say 5 feet to 2 inches, construct one in the following manner:—

Draw an indefinite straight line, AB, and mark off 2 inches, AC. Draw line AD at any convenient angle, and from A on line AD, with dividers opened to any suitable distance, mark 12 equal divisions A to E; open dividers to distance AE, set out four equal distances, EFGHK. Join KC, and from divisions draw parallels to KC, dividing the line AC; then complete the scale as shown in figure 3. If the divisions on the line AD can be conveniently set off direct from a scale,

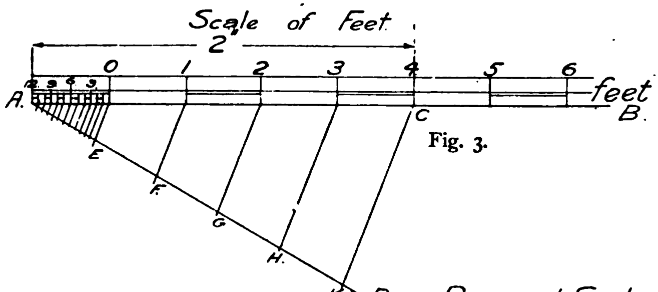


Fig. 3.

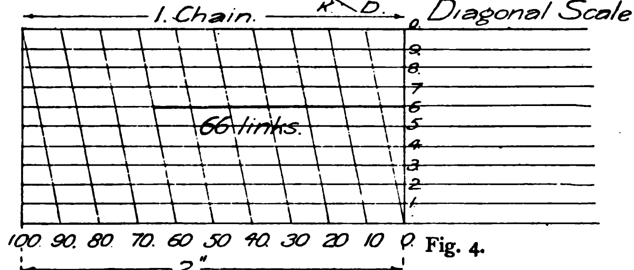


Fig. 4.

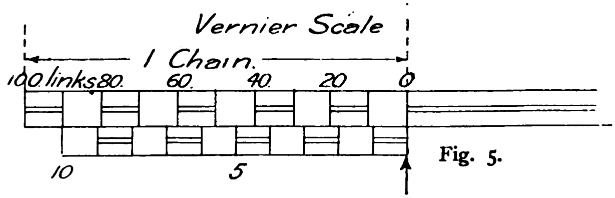


Fig. 5.

this is to be preferred; and, as a rule, mark off dimensions with a scale direct, and thus avoid the unnecessary use of dividers for that purpose.

All drawings on completion should have a scale drawn at the bottom, or in the lower left-hand corner, or wherever it is most convenient, so that dimensions can be measured from it, at any time, the scale and drawing being equally affected by the contraction and expansion of the paper, which is often a material quantity, especially in drawings made to a small scale.

Diagonal Scale.—Where the scale of a drawing is small, such as is the case in plans of land surveys, diagonal scales, as shown in figure 4, are constructed to obtain minute dimensions. Figure 4 shows a diagonal scale, 2 inches to the chain. The scale is constructed to measure links or one hundredths of the chain. It is necessary to take two numbers the product of which equals one hundred. Ten and ten have been taken in this case. The 2-inch line is then divided into ten equal parts and ten other lines parallel to the first are drawn at equal distances apart. Lines are drawn at right angles from the extremities of the 2-inch line forming a rectangle, from the right-hand lower corner of the rectangle shown in figure 4 draw a line to intersect the topmost line in the first division, from each of the other divisions draw parallels to this line. Number the points as shown in figure 4. In this case any measure required must be taken from the line, the number of which agrees with its last figure, thus 66 links would be measured on number 6 line.

Vernier Scale.—This method of measuring is employed where very minute dimensions are required. It is usually applied to measuring instruments, and is employed in lineal and angular measures. It consists of a small movable scale divided into a number of equal parts, each of which bears a definite ratio to the equal dimensions of the main or primary scale to which it is applied; thus, in the example shown in figure 5, a scale of 2 inches to the chain is drawn, divided into ten equal parts each representing ten links; if it is desired to measure to single links by this scale, the vernier or movable scale is made in length equal to 9 parts or 90 links of the main scale, and this length is then divided into ten equal parts, each of these divisions being therefore equal to $\frac{1}{10}$ of 90 links, that is, 9 links.

The difference therefore between the lengths of the first division of the vernier and the first division of the main scale will be one link, between the lengths of two divisions of the vernier and the two divisions of the main scale will be two links and so on. Therefore in using the vernier the length to be measured is placed between zero on the main scale and the arrow head on the vernier, this will give the length up to the nearest ten links; then notice on the vernier the number of the division which coincides with any division on the main scale, and add this to the number previously determined, because this will indicate the difference in links, the vernier has to be adjusted to the nearest ten links below the exact number, to give the dimensions to the nearest link.

Inking in.—Always use a good Indian ink, one rubbed up from the stick in a smooth china saucer is to be preferred, especially if it is to be diluted to obtain gradations in brush work.

Ready-made Indian inks are now produced by many manufacturers, which give good results and save much time in preparation. The bottles should always be kept corked when the ink is not being used, otherwise it rapidly thickens. Waterproof inks are largely made, but for general work are inferior to the ordinary ink, as they tend to dry rapidly and clog the pen.

Inferior Indian inks, which run when drawings are coloured, must on no account be used, as many drawings when coloured are spoilt by the ink running. Should the ink run, the damage may be remedied by immediately washing the whole drawing with plenty of clean water, which will remove all free ink. The water must be carefully removed by means of a piece of clean blotting paper. When stick ink is employed, to ascertain if it is sufficiently mixed for use blow in the saucer or palette, or make a line on paper and smear it; if by either method the ink exhibits a brownish tint instead of a black, it is not mixed sufficiently. In using the ruling pen it should be drawn over the paper, being held in a nearly vertical position; and the pen should always be held in this position, otherwise a variation in the thickness of the line will ensue.

Medium for Reproduction Work.—For this class of work not only is great care necessary, but better results are obtainable by noting the following suggestions.

1st. For black-and-white work the black must be very intense; Indian ink is very good, but if required in large quantities is found somewhat expensive. Stephens's ebony-stain is in most cases a good substitute for Indian ink, but the stain cannot be used where there is danger of water coming into contact with the work.

2nd. For all line drawings, care must be taken that the lines are unbroken, and must be firm and of medium thickness.

Erasure of Lines.—Inked lines may be eliminated as follows:—Take a piece of clean paper and place it over the lines that are to be removed, cutting away a portion of the clean sheet just sufficient to enclose them; then with a clean sponge the lines may be washed out, the remaining portion of the drawing being protected by the covering paper, or they may be scratched out with a sharp penknife worked lightly over the surface, or by a piece of ink eraser. After employing either of the two latter methods, the injured surface of the paper should be burnished with a piece of polished bone or ivory before other lines or colour are passed over the spot.

Cleaning out pencil lines with india-rubber must be done in one direction, as rubbing backwards and forwards destroys the surface of the paper. Drawings, if dirty, should be cleaned with stale bread in preference to india-rubber.

Hatching Sections.—When the drawings are not to be coloured, the materials most commonly used may be denoted in section by lines as shown in figures 6 to 16.

Colouring.—If a drawing is to be coloured, no sectional nor hatching lines are to be drawn; the same colour as that used for elevations, but of a darker tint, is to be laid on for sections, unless otherwise stated.

List of Conventional Colours to be used in Preparing Drawings :—

Gamboge, Raw Sienna, Burnt Sienna, Burnt Umber, Vandyke Brown, Sepia, Venetian Red, Crimson Lake, Cobalt, Indigo, Prussian Blue, Neutral Tint.

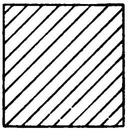


Fig. 6. Brick.

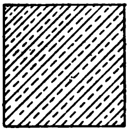


Fig. 7. Stone.

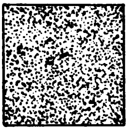


Fig. 8. Plaster.

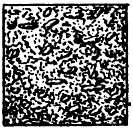


Fig. 9. Concrete.

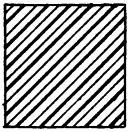


Fig. 10. Wrot. Iron.

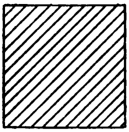


Fig. 11. Cast Iron.

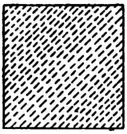


Fig. 12. Steel.

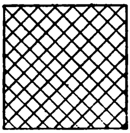


Fig. 13. Lead.

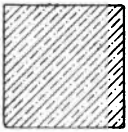


Fig. 14. Brass.

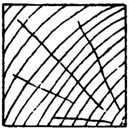


Fig. 15. Wood.

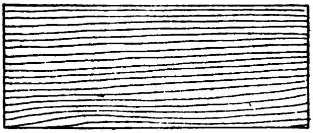


Fig. 16. Wood—Longitudinal Section.

Brickwork.—Elevation, Venetian red or yellow ochre. Section, crimson lake.

Stonework.—Dressings, sepia; rough or hard stone, indigo.

Plaster.—Elevation, light Prussian blue. Section, neutral tint.

Concrete.—Neutral tint.

Wrought Iron.—Prussian blue.

Cast Iron.—Payne's grey.

Steel.—Purple. (Mixture of crimson lake and Prussian blue.)

Lead.—Indigo.

Brass.—Gamboge.

Oak.—Sepia and a tinge of yellow.

Fir, unwrought and floors.—Raw sienna. Sections, streaked with burnt sienna.

Wrought Fir.—Burnt sienna.

Mahogany.—Crimson lake, sepia, and burnt sienna.

Tiles.—Venetian red and a little yellow.

Slates.—*Green,* indigo and yellow; *Purple,* indigo and crimson lake.

Walnut.—Sepia and burnt sienna.

Glass, interior.—Flat wash of cobalt.

Glass, exterior.—Flat wash of Indian ink, or a wash of indigo.

Generally.—In elevation all washes should be light, while sections should have darker tints of the colours similar to those used for the elevation.

It is sometimes necessary to mix colours, but as a rule this method of obtaining tints should not be adopted, as it is extremely difficult to obtain the required tint, and then to match it again. When mixing colours care should be taken to have a quantity sufficient for the work in hand. Each time a mixed tint is taken from the palette, the whole should be stirred with a brush.

Any of the following tints may be mixed from the colours given in the list of conventional colours. Burnt umber: sepia and burnt sienna. Indian yellow: gamboge and pale burnt sienna. Hooker's green (glass in section): Prussian blue and gamboge. Payne's grey: indigo, Indian ink, and crimson lake.

Colouring.—It is usual before colouring to ink in the lines of architectural drawings, as alterations after colouring disfigure the work. Where the washes of colour are large it is advisable to damp the paper to obtain an evenness of tint. Care should be taken in colouring an inked drawing that the brush is not worked too much over the lines as there is a danger of the ink running, so, to avoid this, many colour first and ink after. This has the advantage of giving brilliant black lines. Light colours should precede dark ones. Colour all parts to be of the same tint, straightway. Avoid the mistake of mixing colours of too dark a tint. If a dark tint is required, a second wash may be applied when the first wash has dried. Sable or camel-hair brushes should be used, and care must be taken to select such as have good sharp and not long straggling points.

Dimensions.—All the leading dimensions should be distinctly figured in. Inattention to this precaution may produce serious mistakes. The extent of the dimensions should be shown by neat arrow-heads connected by a continuous thin blue line broken only in the middle, the dimensions being inserted in this space in a vertical position, and all to read one way. Internal dimensions should be taken between the brick or stone walls, also between floor levels.

Lettering.—For titles and headings, Egyptian or block upright letters are effective. Roman letters are satisfactory and easier to form, while for general and descriptive writing an easily written form of small upright block italics is to be preferred.

Specimen Upright Block—Capitals.

A B C D E F G H I J K L M N O P Q
R S T U V W X Y Z
1 2 3 4 5 6 7 8 9 0

Specimen Upright Block—Small.

a b c d e f g h i j k l m n o p q
r s t u v w x y z

Specimen Upright Roman—Capitals.

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z
1 2 3 4 5 6 7 8 9 0

Specimen Upright Roman—Small.

a b c d e f g h i j k l m n o p q
r s t u v w x y z

Specimen—Italics.

a b c d e f g h i j k l m n o p q r s t u v w x y z
1 2 3 4 5 6 7 8 9 0

Geometrical Explanations—Measurements.—Throughout this treatise a single accent (′) signifies feet, a double accent (″) inches, and (°) degrees.

Plan.—If the boundaries of the surfaces of solids are imagined to be projected in paths, or by lines perpendicular to a horizontal plane, that portion of the horizontal plane enclosed by the projectors is called the plan, and thus there may be roof plans, floor plans, basement plans, etc.

Elevation.—In a similar manner the space covered on a vertical plane by projectors perpendicular to the vertical plane, from a solid, is the elevation; and therefore front elevations, back elevations, side elevations, etc., are so called after the sides seen.

Section.—Where a plane or imaginary plane divides a solid, the cut surfaces are called sections, and there may be cross (or transverse) sections, longitudinal sections, vertical, and horizontal sections.

Sectional Plans or *Elevations* are the projections of a cut surface, and any remaining uncut part of the solid.

The parts seen from the outside in plan or elevation (always being perpendicular to the plane that projectors are being taken from) are drawn in firm lines, those unseen in dotted lines, to indicate their position.

Isometric Projection.—It is often convenient, especially for details of solids with rectangular faces, to show the three dimensions in one view. This may be accomplished by drawing three lines meeting in a point containing equal angles of 120°, representing length, breadth, and depth, to scale, and from the free extremities of these lines draw lines parallel to the other two. This method is misleading for angular and curved work, as it gives distorted views, and all lines not parallel to any one of the three axes cannot be measured accurately with the scale used. It is usual to work with the ordinary scales.

Perspective Drawing.—This is the science of making representations of objects as they appear to the eye, and is very useful for showing how a proposed object will appear when made, and for illustrating details.

Tracing.—An original drawing is made of all proposed work; from this standard drawing a number of copies are often required to be made. The copies are made by tracing or by photography.

For comparing the plotting of different stories during the process of designing, tracing paper is commonly used; but copies of drawings that are to be much used are usually traced upon linen, which offers a greater resistance to tearing. The glazed side is usually inked and the coloured washes placed upon the back. There is often a difficulty in getting the ink to flow uniformly upon the glazed surface of the linen, but to overcome this obstacle a little oxgall is mixed with the ink; or chalk may be rubbed upon the glazed surface of the linen for the same purpose.

Black Line, Water-bath Reproduction.—A tracing in ink is made from an original, which need not necessarily be in ink, upon white or bluish tinged tracing paper or tracing cloth. Yellow tracing paper must be avoided for this purpose, as the actinic power of the rays of light is reduced in passing through this coloured medium. The tracing is placed against the glass of a printing frame (such as is used in photography) in front of specially prepared sensitized paper in a dark room, and the frame is then closed and exposed to the direct and uninterrupted rays of light.

Sufficiency of exposure is indicated when the blank surface of the sensitized paper (that is, the part not covered by the ink lines on the tracing) turns from the yellow to the natural whiteness of the back of the sensitized paper. Then the print is held under running water till the black lines are developed, and the yellow coating which turns black on contact with the water is washed away.

The required exposure ranges from five minutes in bright sunshine to one hour in dull weather.

This method is now extensively used.

White Lines on Blue Ground.—This method, known as the ferro-prussiate process is largely used for the reproduction of drawings that do not require colouring afterwards, and is accomplished in the following way:—A tracing is made from the original as in the previous method, it is placed in a printing frame with its face against the glass, the printing paper is then placed in the frame with its sensitized face in contact with the tracing, the frame is then closed and the exposure made, the time taken varying, according to the intensity of the light, from five minutes in bright sunshine to one hour in dull weather. The print is then washed in running water. This method gives white lines on a bright blue surface, and is much used for engineering drawings.

Manifolding of Writing.—Mechanical means should always be used to reproduce specifications, quantities, etc., as every copy will then be exactly similar. There are three methods largely employed: (1) typewriting with carbon paper, when not more than six copies are required. (2) By writing or typewriting on specially prepared stencil paper, which is placed in a printing frame, paper is placed on the bed of the machine, the printing frame, which is hinged, is lowered till the stencil is in contact with the sheet on which the copy is to be made—the upper side of the stencil having been previously covered with ink—a roller is run over the upper surface, this produces the impression, the frame is opened, the copy removed and the operation is repeated. Five hundred copies may be made by this method. There are many modifications of this stencil principle. (3) By lithography: a copy is made by hand from the original documents upon specially prepared paper, which is then pressed on to the face of a specially prepared stone, this leaves an impression. The stone is then subjected to chemical action and the impression made permanent. From this thousands of copies may be printed.

CHAPTER II.

BRICKWORK.

Definition.—Brickwork is the art of arranging and bedding bricks in either lime or cement mortar, to unite them and form a homogeneous mass of a desired shape with sufficient stability to resist safely the stresses to which it is to be subjected.

Walls.—Walls made with bricks are practically fences, generally vertical, and enclose areas or support earth or water. They consist of base, body, and cornice or coping. The base is usually extended in a transverse direction either by battering or by offsets, technically known as footings, to distribute the pressure of the wall above over an area sufficiently great to carry the load. Damp is prevented from rising from the ground up walls by a horizontal course of damp-resisting material, which must be placed at a height sufficient to prevent a driving rain splashing up and wetting the wall above the damp course, and as low as possible to reduce to a minimum the amount of the wall wetted by capillary attraction, usually a distance of 6 inches or not more than one foot above the ground level is found to be most suitable. Water is prevented from passing down from the top of walls by a damp-proof course which may consist of a stone coping weathered sufficiently to throw off all water rapidly, and with a cornice the purpose of which is to throw all water coming upon it as far as possible from the body and base of the wall.

Wall Classification—

1. Walls of uniform thickness.
2. Walls buttressed and with curtain walls.
3. Retaining walls.

1. Walls of uniform thickness, solid and hollow as shown in figures 17 and 18. These are employed where the weights from floors, roofs, etc., to be supported are evenly supported over the length of the wall. The space in a hollow wall is arranged for the further purpose of rendering the temperature within the building less subject to variations, and also to prevent damp passing through from the exposed face. The two walls are connected together with stoneware or iron ties, as shown in figures 20 to 22 spaced as shown in figure 19.

2. The buttressed and with curtain walls. These are of two kinds (*a*) where the loads to be supported are concentrated at points as from the trusses of roofs, in which case it is unnecessary to have the walls of uniform thickness throughout the length, buttresses being constructed to resist the thrusts of trusses, and comparatively thin walls being built to connect the buttresses to complete the enclosure as shown in figures 23 to 25; (*b*) where the weights from floors are concentrated at intervals by means of girders as in double floors. It is necessary only to have piers of a horizontal area sufficient to resist the superincumbent pressures, these being connected by thin curtain walls as shown in figures 26 to 28. As in these cases the weights are concentrated at intervals on the foundations, it is frequently necessary to connect the piers near their bases with inverted arches to distribute the pressures equally over the whole of the foundation, as shown in figure 26.

3. These include retaining walls or revetment walls and dams. Revetment walls are designed to support masses of earth, as in cuttings, as shown in figures 29 to 31. These may be constructed (*a*) with a vertical face; (*b*) with a straight batter; (*c*) with a curved batter; generally for similar embankments most wall material is required for method (*a*), and the minimum quantity for method (*c*) those designed only to protect the face of a cutting the strata of the earth on the sides of which are inclined away from the cutting and in a down-

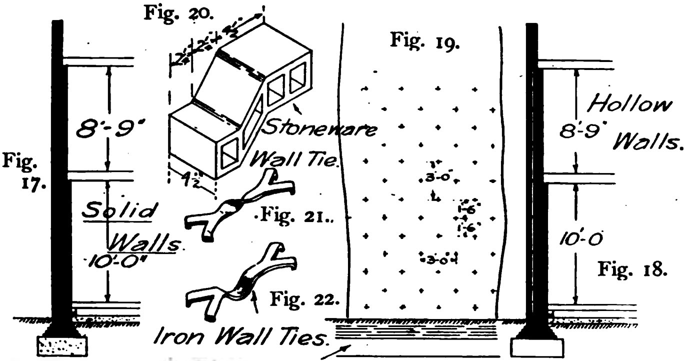


Fig. 17. Fig. 18. Fig. 19. Fig. 20. Fig. 21. Fig. 22.

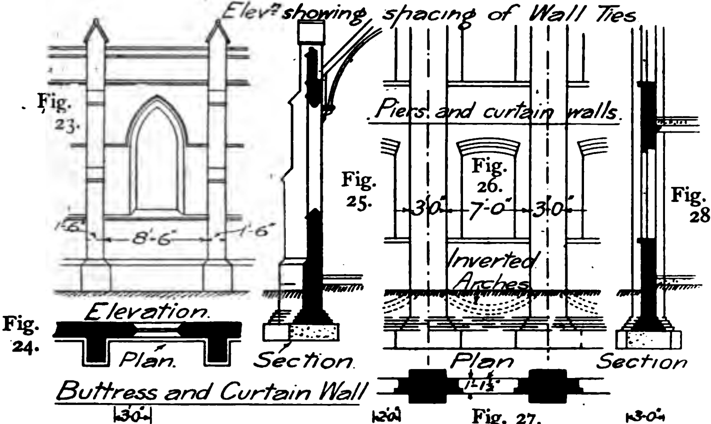


Fig. 23. Fig. 24. Fig. 25. Fig. 26. Fig. 27. Fig. 28.

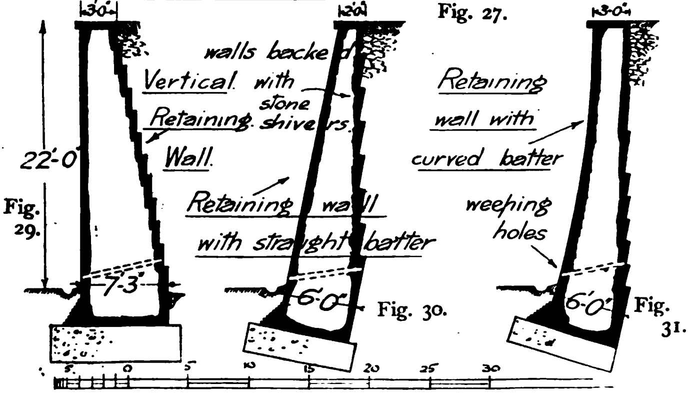


Fig. 29. Fig. 30. Fig. 31.

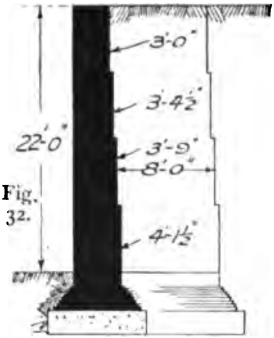


Fig. 32.

Sec^n. Elevation

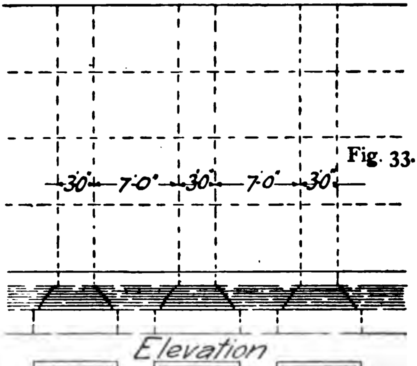


Fig. 33.

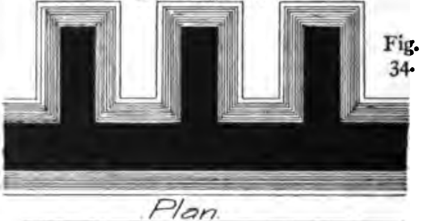


Fig. 34.

Retaining Wall with Counterforts behind

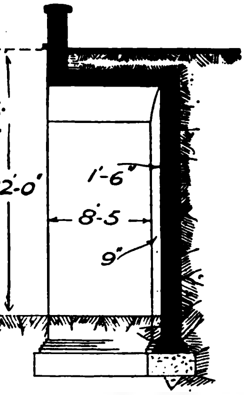


Fig. 35.

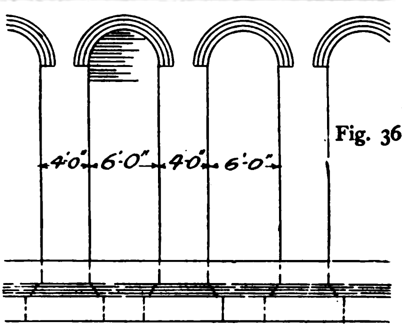


Fig. 36.

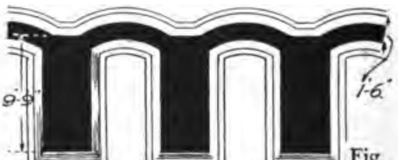


Fig. 37.

Horizontal Arches and Buttresses.

ward direction, and are not likely therefore to fall *en masse*, but only liable to decompose and fret away under the action of the atmosphere, are known as breast walls. High retaining walls are frequently constructed (1) with counterforts behind, as shown in figures 32 to 34; (2) as a series of horizontal arches with heavy abutments in front. It is usual to arch over the spaces between the abutments, as shown in figures 35 to 37, or (3) the earth may be maintained by a series of relieving arches into the spaces, beneath which the earth is allowed to assume its natural slope, a thin wall usually being built in front of the relieving arches to present a fair face, as is shown in figures 38 and 39. Dams are retaining walls constructed to resist the pressure of water. This subject is continued in the Advanced Course.

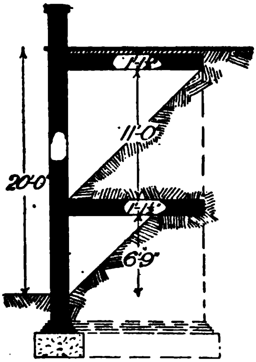


Fig. 38.

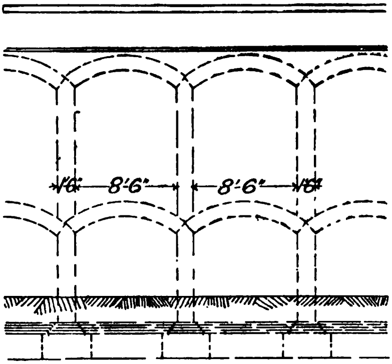


Fig. 39.

Relieving Arches.

Stability of Brickwork.—There are three general ways in which the stability of brickwork may be affected:—1st, by concentrating too great a weight on a given area of ground, or by the ground being soft, or inclined to slide, in which case the walls are thrown out of the upright, crack, or disintegrate, see Chapter on Foundations, *Advanced Course*; 2ndly, by being badly bonded, in which case the tie between the bricks will be insufficient and disintegration follows (this may be remedied by bonding according to the arrangements shown later); 3rdly, by insufficient transverse resistance, which may be compensated for by building all walls of a thickness proportional to their height, by preparing for all side thrusts or wind stresses, by taking care that all courses are bedded truly, and sufficiently strengthened by cross walls or special buttresses, and if likely to be thrown under a tensile stress that they be bedded in some tenacious mortar.

Dimensions of Bricks.—The average size of a good stock brick is 8¾″ long, 4¼″ wide, and 2¾″ thick, and the dimensions, including one mortar joint, in this work, unless otherwise stated, will be taken as, length 9″, width 4½″, and thickness 3″. Bricks are usually bedded on the 9″ × 4½″ surface in lime or cement mortar, the top surface having an indentation, or frog, as it is sometimes called, which affords a good key for the mortar, as shown in figures 40 and 41.

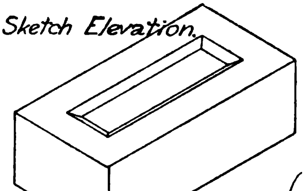


Fig. 41.

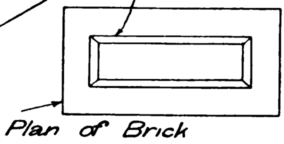


Fig. 40.

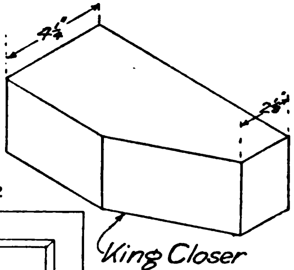


Fig. 42.

In the north of England, bricks are often made up to 4 inches in thickness. For partition walls, special bricks 6 inches in width are made

Bedding of Bricks.—Bricks are bedded in mortar, 1st, to distribute the pressure more evenly over the bricks; 2ndly, to obtain adhesion and thus give homogeneity to the mass; 3rdly, by filling up the interstices, to make the walls weather proof.

Bricks are wetted or soaked before being used in order to remove loose dust, to afford better adhesion for the mortar, and to prevent the bricks absorbing too much moisture from the mortar.

Mortar.—The mortar is composed of one of lime to two or three parts of sand, or from one of Portland cement to one to four of sand. Lime mortar sometimes has cement added to it to increase its strength and hasten its setting.

Lime mortar should not be used when fresh or in an untempered condition, as in that state its cohesive value is small and it is difficult to work; but after making should be left two days at least, then turned over and beaten up again.

This tempering gives it the property of working evenly and fat. Cement mortar should be used as soon after making as possible, as the setting action commences immediately after mixing and any further working-up of the mortar lowers its ultimate strength.

Effect of Frost.—Brickwork is best carried out when the temperature is above the freezing point, for in the event of frost occurring during the progress of the work the water in the mortar expands and overcomes the cohesion of the particles. Works executed during times when frost may be expected should be protected by covering all top surfaces between the intervals of working upon any point.

Technical Terms.—*Course* is the name given to the row of bricks between two bed joints, and the thickness is taken as one brick plus one mortar joint, in this work; unless otherwise stated, it will be considered as 3″ or, as technically described, four courses to the foot.

Bed Joints.—The mortar joints between the courses opposed to the pressure.

- (*a*) In walls with vertical faces the bed joints would be horizontal.
- (*b*) In batter walls they would be at right angles to the batter.
- (*c*) In arches they come between the voussoirs.

Quoins.—The external corners of walls. The name is sometimes applied to the bricks or stones which form the quoins, *e.g.* quoin brick, quoin stone.

Perpends.—The vertical joints of the face of the wall. Where they fall immediately over each other in alternate courses, the perpends are said to be kept.

Stretchers.—Bricks laid with their lengths of 9″ on the face of the wall or parallel to the face of the wall.

Headers.—Bricks laid with the width of 4½″ on the face of the wall or parallel to the face of the wall.

Bats.—Pieces of bricks, and are usually known, according to their fraction of a whole brick, as ½ or ¾ bats.

Lap.—The horizontal distance between the vertical joints in two successive courses. This should be 2¼″.

Queen Closers.—Bricks made the same length and thickness as ordinary bricks, but half the width. Owing to the quantity broken in cartage, the extra expense is usually an objection, and bricklayers form the closers economically by cutting their broken bricks into ¼ brick bats and placing two together to form closers, as shown in figures 45 to 53. This is easier and not nearly as wasteful as cutting an ordinary brick lengthwise in two.

King Closers.—Bricks cut so that one end is half the width of the brick, as shown in figure 42. They are used in positions where the greater width at the back adds strength to the bond. They usually occur at rebated openings in Flemish bond walls.

Bond (that is, to bind), the name given to any arrangement of bricks in which no vertical joint of one course is exactly over the one in the next course above or below it, and having the greatest possible amount of lap.

Bonds in Brickwork.—Bond in brickwork is the method of arranging each brick so that it laps over the bricks with which it is in contact above and below a distance equal to ¼ the length of the brick. To ensure good bond the following rules should be rigidly adhered to:—1st, the arrangement of the bricks must be uniform, and as few bats as possible be employed; 2ndly, a closer to be inserted after the quoin header in any course; 3rdly, the vertical joints in every other course to be perpendicularly in line on the internal as well as the external face; 4thly, stretchers are only to be used on the faces of the wall, the interior to consist of headers only, except in footings and corbels; 5thly, the dimensions of bricks should be such that when bedded the length should equal twice the width, plus one mortar joint.

Facing Bond.—Hindrances to good bond often occur when facing bricks used are costly or of different lengths and widths to the body of the wall; in 9″ walls, where it is necessary to have two fair faces, very frequently facing headers are cut off, being an easy as well as a cheap method of overcoming the difficulty; but this weakens the wall to a large extent, and it would be better to bond in only every third or fourth course; a method known as facing bond as shown in figure 81.

There are several kinds of bond used in brickwork. Those described in this chapter being as follows:—1st English, 2nd Double Flemish, 3rd Single Flemish, 4th English Cross,

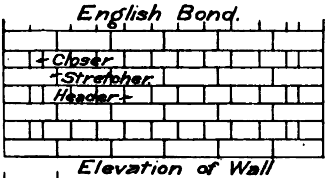


Fig. 43.

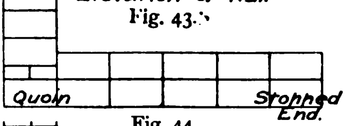


Fig. 44.

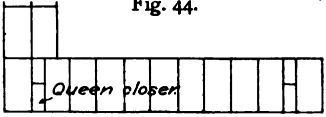


Fig. 45.

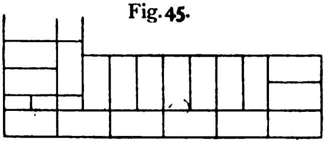


Fig. 46.

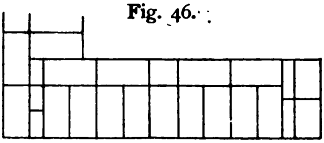


Fig. 47.

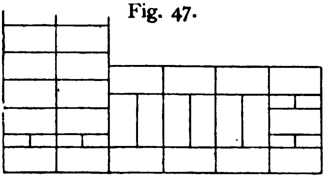


Fig. 48.

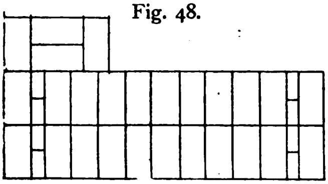


Fig. 49.

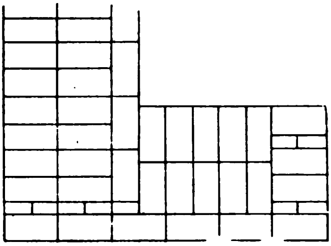


Fig. 50.

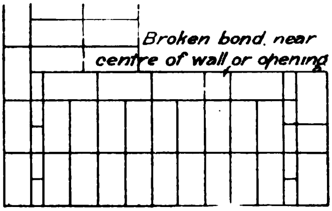


Fig. 51.

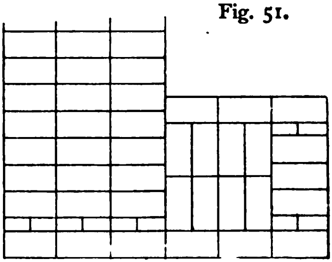


Fig. 52.

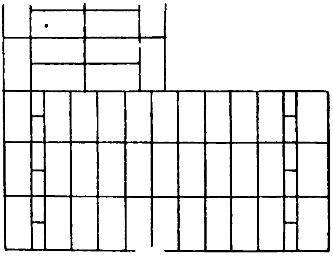


Fig. 53.

Figs. 43–53. Examples of English Bond.

5th Dutch, 6th Stretching or Chimney, 7th Heading Bond, 8th Sussex Bond, 9th Raking Bonds, 10th Hoop Iron.

English Bond.—When the bond is arranged as shown n elevations and plans, figures 43 to 53, it is known as English bond, and sometimes old English bond. It consists of one course of headers and one course of stretchers alternately. In this bond bricks are laid as stretchers only on the boundaries of courses, thus showing on the face of the wall, and no attempt should be made to break the joints in a course running through from back to front of a wall. That course which consists of stretchers on the face is known as a stretching course, and all in course above or below it would be headers with the exception of the closer brick, which is always placed next to the quoin header to complete the bond, and these courses would be called heading courses.

It may be noticed that in walls the thickness of which is a multiple of a whole brick, the same course will show either—

(*a*) Stretchers in front elevation and stretchers in back elevation.
(*b*) Headers ,, ,, ,, headers ,, ,,

but in walls in which the thickness is an odd number of half bricks, the same course will show either—

(*a*) Stretcher in front elevation and header in back elevation.
(*b*) Header ,, ,, ,, stretcher ,, ,,

In setting out the plan of a course to any width, draw the quoin, or corner brick; then next to the face (which in front elevation shows headers) place closers to the required thickness of wall, after which set out all the front headers, and if the thickness is a multiple of a whole brick, set out headers in rear; if the thickness is an odd number of half bricks, set out stretchers in rear: the intervening space, if any, is always filled in with headers.

Double Flemish Bond has headers and stretchers alternately in the same course, both in front and back elevations,

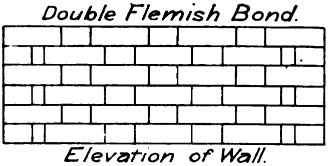


Fig. 54.

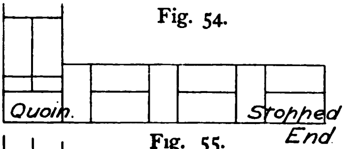


Fig. 55.

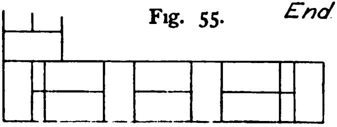
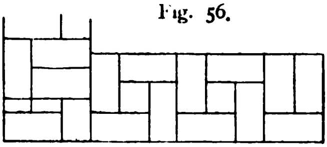


Fig. 56.



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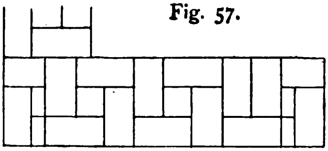

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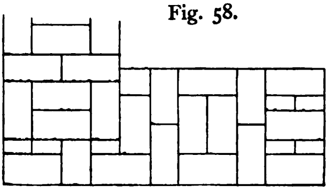

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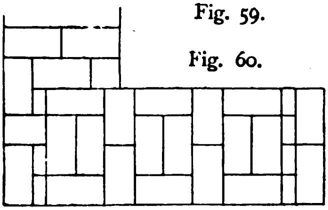

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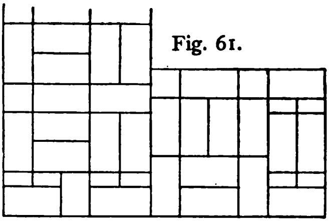

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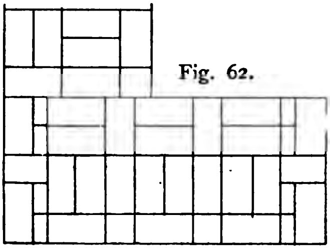

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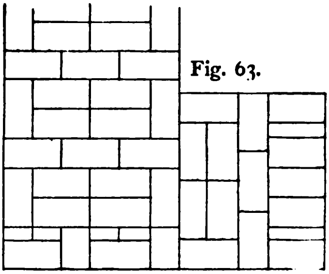

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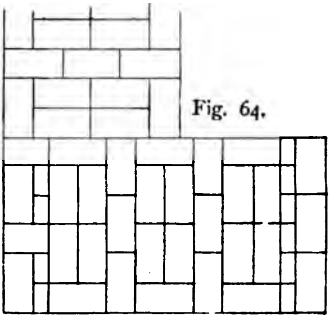
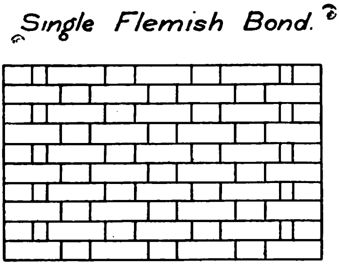


Fig. 64.

Figs. 54-64. Examples of Double Flemish Bond.

Fig. 65.



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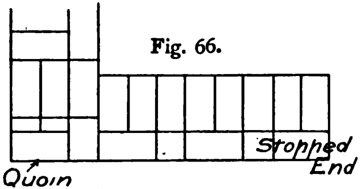

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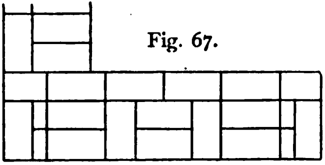

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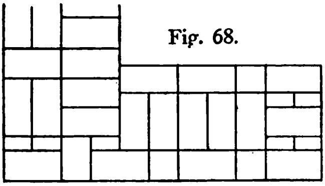
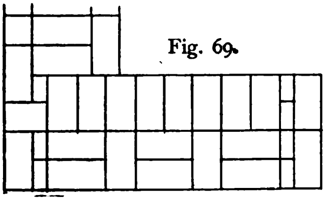


Fig. 69.



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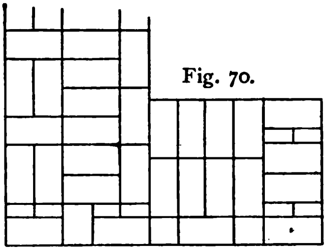

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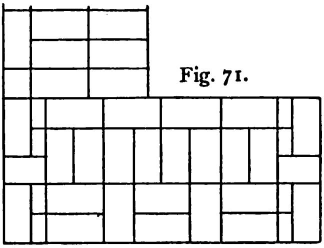

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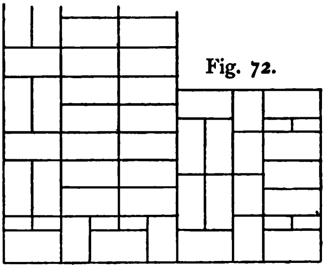
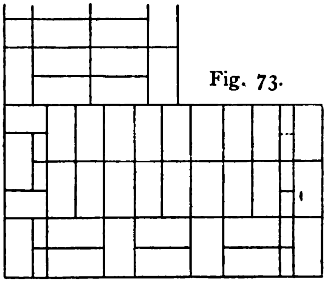


Fig. 73.



Figs. 65–73. Examples of Single Flemish Bond.

as shown in figures 54 to 64. It is weaker than English bond, owing to the greater number of bats and stretchers, but is considered by some to look better on the face. It is also economical, as it admits of a greater number of bats being used, so that any bricks broken in transit may be utilised. By using double Flemish bond for walls one brick in thickness, it is easier to obtain a fair face on both sides than with English bond.

Single Flemish Bond consists in arranging the bricks as Flemish bond on the face, and English bond as backing. This is often done on the presumption that the strength of the English bond as well as the external appearance of the double Flemish is attained, but this is questionable. It is generally used where more expensive bricks are specified for facing. The thinnest wall where this method can be introduced is 1½ brick thick. Plans of alternate courses are given, figures 65 to 73. The front elevations are the same as in double Flemish bond.

English Cross Bond.—A class of English bond. Every other stretching course has a header placed next the quoin stretcher, and the heading course has closers placed in the usual manner.

Dutch Bond.—In every alternate stretching course a header is introduced as the second brick from the quoin, three-quarter bricks are used in the remaining stretching courses at the quoins, and the closers are dispensed with in the heading courses, as shown in figures 74 to 79; the longitudinal tie becomes much greater, and the appearance of the elevation is certainly superior to much of the inferior work one is accustomed to see as examples of the modern bricklayer's skill in bonding. Should there be a fracture, it is supposed to throw it more obliquely.

Stretching Bond should be used only for walls half brick

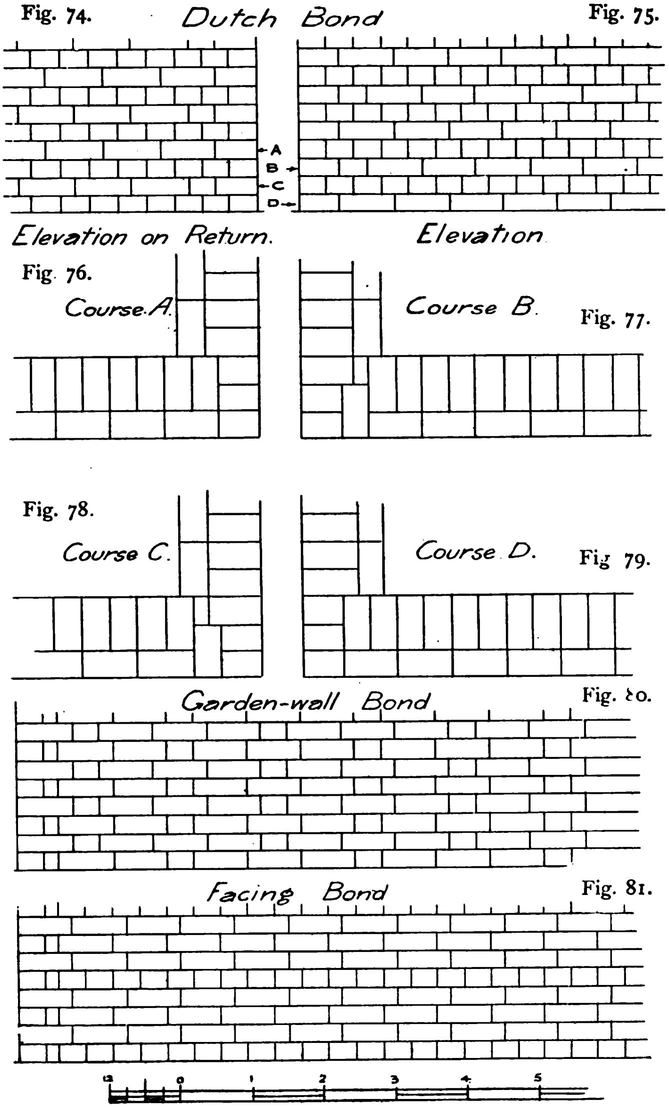
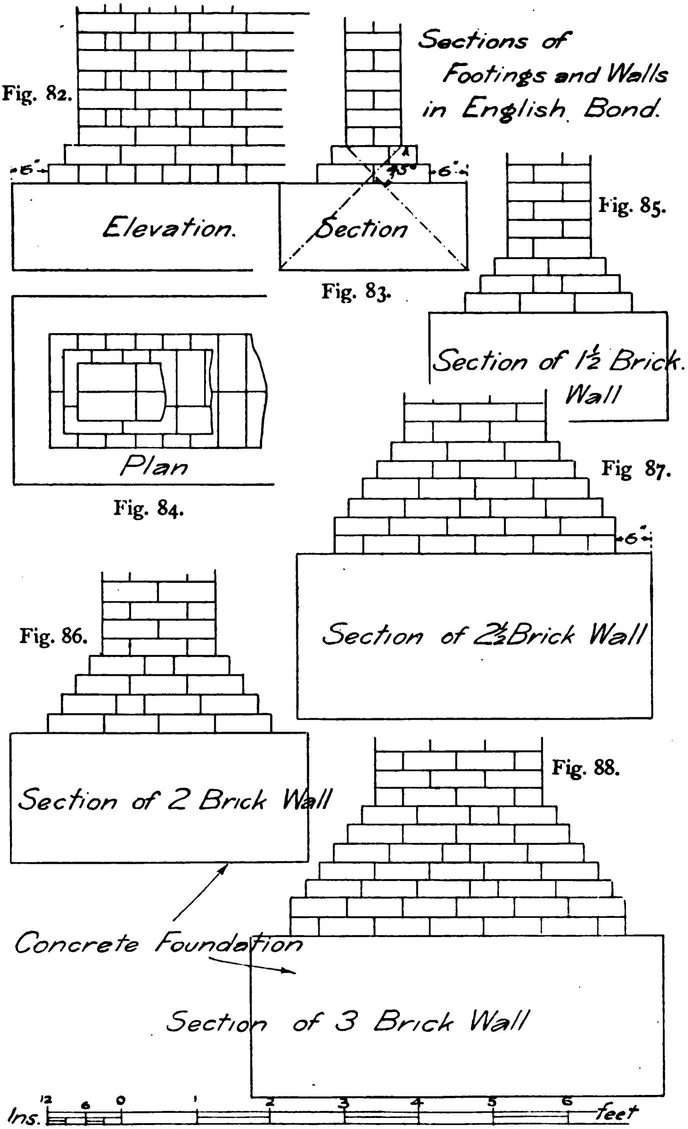


Fig. 74.
Dutch Bond
Fig. 75.
A
B
C
D
Elevation on Return.
Elevation
Fig. 76.
Course A.
Course B.
Fig. 77.
Fig. 78.
Course C.
Course D.
Fig 79.
Garden-wall Bond
Fig. 80.
Facing Bond
Fig. 81.
12
0
1
2
3
4
5

Figs. 74–81.



Figs. 82–88. Sections of Footings and Walls in English Bond.

thick, as for partition walls. All bricks are laid as stretchers upon the face.

Heading Bond.—All bricks show as headers on face. Used chiefly for rounding curves, for footings, corbels and cornices.

Footings.—These are the wide courses placed at the base of a wall to distribute the pressure over a greater area of ground. The course coming immediately upon the concrete should be twice the required width of the wall; thus, in a two-brick wall this course would be four bricks wide. Offsets of 2¼" are then made on each side of each successive course till the desired thickness is obtained. Walls of two or more bricks in thickness frequently have their bottom courses of footings doubled, as shown in figures 87 and 88.

Care should be taken that the bricks in footings should be laid as far as possible as headers, but if stretchers are required in any course they should be laid near the centre of the wall.

Figures 82 to 88 give sections of footings and walls in English bond from one to three bricks in thickness. Trenches in practice are excavated for beds of concrete from 9 inches and upwards in depth, and 12 inches wider than base of footings (6 inches on each side). Hatching lines in the sections are omitted for the sake of clearness.

Seddon recommends that brick footings be dispensed with, and a deep bed of good cement concrete substituted for the footings and concrete foundation; where ballast is found on the site this is often a more economical practice.

Corbelling.—It is sometimes considered expedient to support loads by the method of brick corbelling, which consists of one or more courses projecting the required distance from the wall.

There are two points that have to be considered in corbelling. The first is, that as every projecting brick is acting as a cantilever the end of the brick should be tailed into the wall as far as possible. To obtain this, as many headers as are available are used. Secondly, the projection of every course over the one below should not exceed 2¼ inches; but it is better if it is only 1⅛ inch. Corbelling renders the walls less stable by bringing the centre of gravity of the mass nearer the internal edge of the wall. Figures 89 and 90 give two examples. Stone and iron corbellings are shown in the chapters on Masonry and Floors.

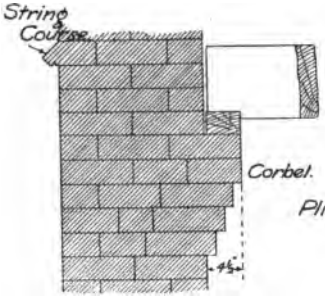


Fig. 89.

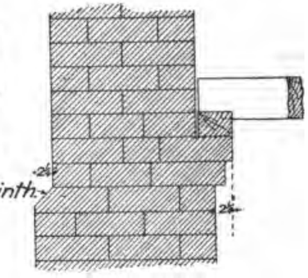


Fig. 90.

Brick Cornices.—Cornices are carried out in moulded bricks upon the principles of corbelling. Where a large drip is required in the cornice, as shown in figures 91 and 92, the modillions are formed of stone, to obtain the necessary tailing in of the corbel.

Raking Bonds.—Walls as they increase in thickness increase in transverse strength; but become proportionally weaker in a longitudinal direction, owing to the fact that stretchers are not placed in the interior of a wall. This defect is remedied by using raking courses at regular intervals, of from four to eight courses in the height of a wall. The joints of bricks laid in this position cannot coincide with the joints of the ordinary courses directly above or below, the inclination to the face usually being determined by making the longitudinal distance between the opposite corners equal to the length of a brick. It is not advisable to use one raking course directly above another, as there is always a weakness with the face bricks at the junction of the raking.

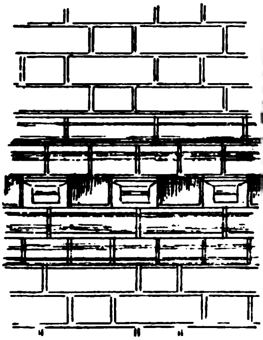


Fig. 91.

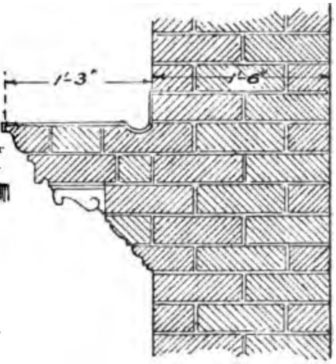


Fig. 92.

Raking bonds are always placed in the stretching courses in walls of an even number of half bricks in thickness, in order that their influence may extend over a greater area than would be the case if they were placed in the heading courses.

The alternate courses of raking bonds should be laid in different directions, in order to make the tie as perfect as possible.

There are two varieties of raking bonds, viz. diagonal and herring-bone.

Diagonal Bond.—This is used in the thinner walls, *i.e.* between two and four bricks in thickness. The operation is as follows:—The face bricks are laid, one or more bricks (in the latter case placed end to end) are bedded between the face bricks, so that the opposite corners touch the latter, this determines the angle that the bricks should be laid, the triangular spaces at the ends of the bricks being filled up with small pieces of brick cut to shape, as shown in figure 93.

Herring-bone Bond.—The bricks in this method are laid at an angle of 45°, commencing at the centre line and working towards the face bricks. Herring-bone bond is used for walls four bricks and upwards in thickness. Figure 94 shows this method.

Diagonal and herring-bone patterns are often used to form ornamental panels in the face of walls, and also in floors paved with bricks.

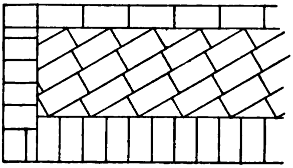


Fig. 93.

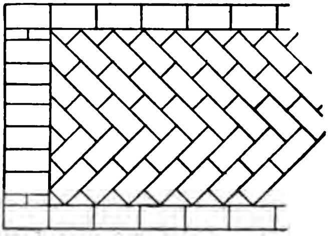


Fig. 94.

Garden or Boundary Wall Bond, Sussex Bond, Scotch Bond, are the names given to walls built with three stretchers and one header in same course, constantly recurring, as shown in elevation, figure 80. This method is used for walls one brick thick that are seen on both sides, as it is easier to adjust the back face by decreasing the number of headers, the lengths of which usually vary.

Hoop-Iron Bond.—An additional longitudinal tie termed "*hoop-iron bond,*" is often inserted in walls, being usually pieces of hoop iron 1" by $\frac{1}{16}$", one row for every half brick in the thickness of the wall, as shown in figure 95. It should be carefully tarred and sanded or galvanized before using to prevent oxidation. It is hooked at all angles and junctions, as shown in figures 96 and 97. If bedded in two courses in cement, additional strength is gained; pieces of hoop iron may be used with advantage where the bond at any part of the wall is defective.

Junctions of Cross Walls.—The bond is obtained in cross or party walls abutting against main walls by placing a closer 4½″ from the face in every alternate course in the main wall, thus leaving a space 2¼″ deep and of a length equal to the thickness of the cross wall for the reception of the 2¼″ projection in every other course of the cross wall, as shown in figures 98 to 103.

Figures 104 and 105 illustrate the junction of one-and-a-half brick Flemish bond with one brick English bond.

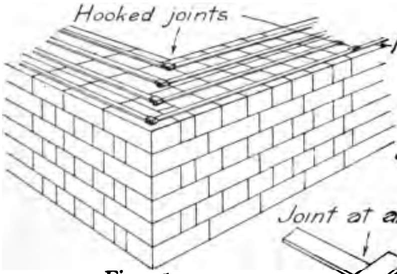


Fig. 95.

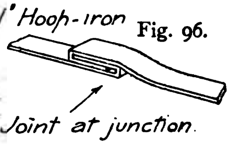


Fig. 96.

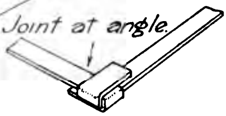


Fig. 97.

Plinth.—A horizontal and usually projecting course built at the bases of walls, as in figure 90, to protect walls from injury and give additional strength.

String Course.—The name given to horizontal courses, sometimes projecting and moulded, built in the faces of walls, anywhere between plinth and cornice, as in figure 89, to act as a tie, and architecturally to emphasize the horizontal divisions of a building.

Copings.—Coverings of walls constructed in brick or stone set in cement to form waterproof tops to prevent rain percolating

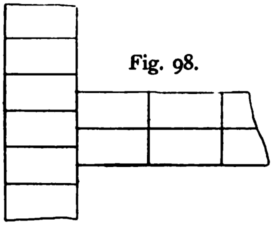
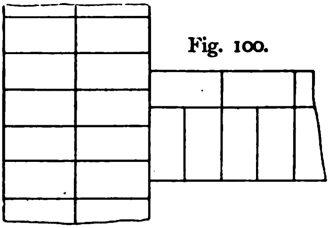


Fig. 98.



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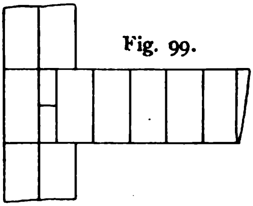


Fig. 99.

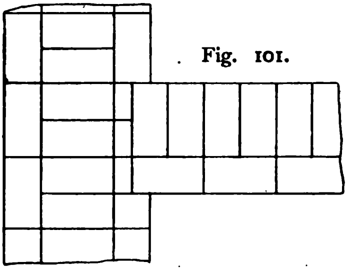


Fig. 101.

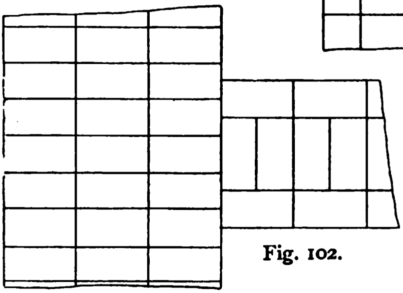


Fig. 102.

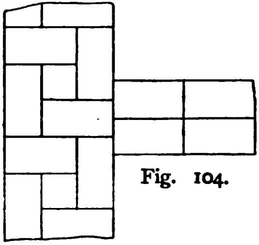


Fig. 104.

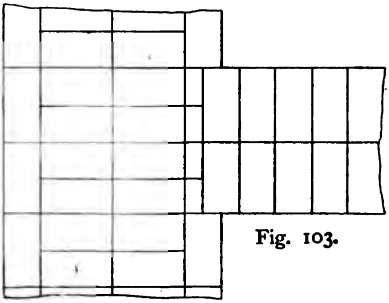


Fig. 103.

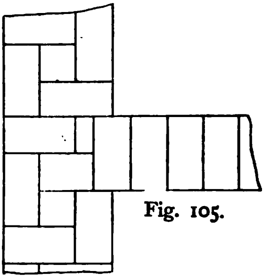


Fig. 105.

Figs. 98–105. Junctions of Cross Walls.

into the interior of walls. Five sections are shown in figures 106 to 110.

Reveals.—The vertical sides of window or door openings between the face of wall and window or door frames. The horizontal distance between is the clear span of opening.

Jambs are the vertical sides of an opening, and in rebated window or door openings there are the internal jambs and the external jambs, the latter being known as the reveals.

Internal jambs are usually covered with plaster, or wood linings.

Figures 111 to 121 show brick reveals, with rebated jambs in English bond.

Fig. 106.

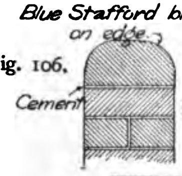


Fig. 107.

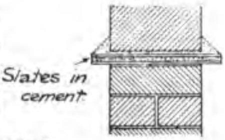
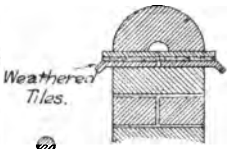


Fig. 108.



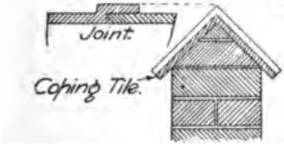


Fig. 109.

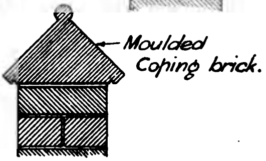


Fig. 110.

Piers.—Piers in brickwork, as shown in figures 122 to 130, are rectangular pillars constructed to support heavy weights transmitted to them by beams and girders, or to receive the thrusts of two or more arches, the resultant of the thrusts of which falls in a vertical line.

Figures 122 to 126 show plans of square piers built in English bond, one to three bricks square. It is only necessary to draw the plan of *one* course, as the adjoining courses have

Fig. 111.

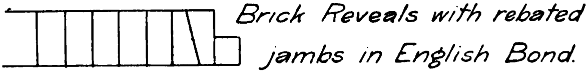


Fig. 112.

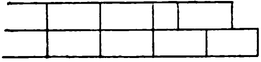


Fig. 114.

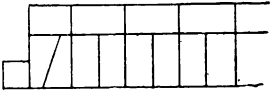


Fig. 115.

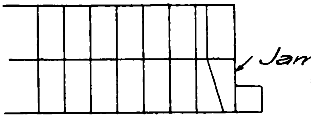
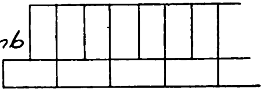


Fig. 113.



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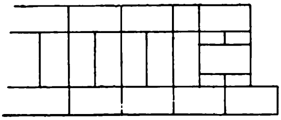


Fig. 117.

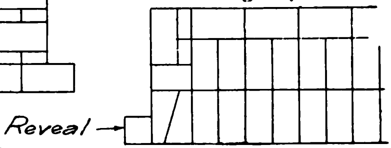


Fig. 120.

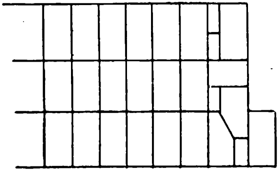


Fig. 119.

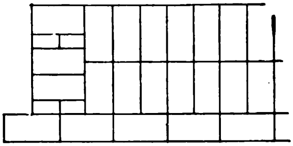
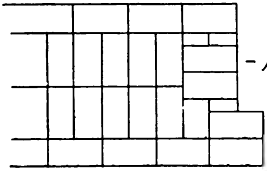


Fig. 118.



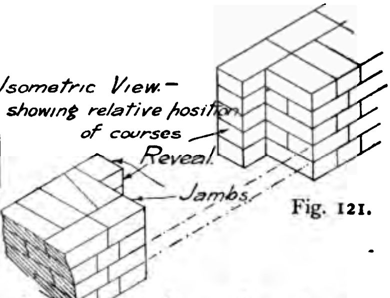
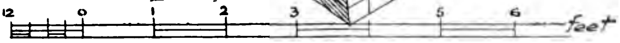


Fig. 121.



Figs. 111-121. Brick Reveals with rebated jambs in English Bond.

the same arrangement of bricks, but placed in such a manner that those in the front elevation of one course are in the side elevation of the next, above or below.

Figures 127 to 130 show plans of square piers built in double Flemish bond one-and-a-half to three bricks square.

Fig. 123.

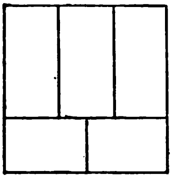


Fig. 122.

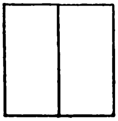
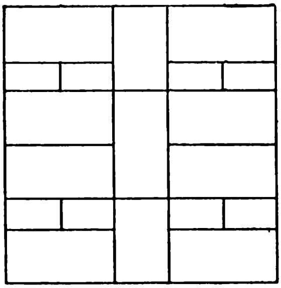


Fig. 125.



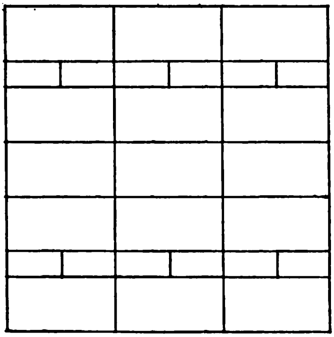


Fig. 124.

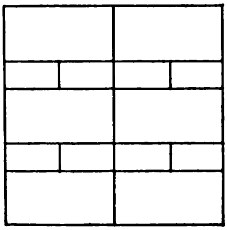


Fig. 126.

Abutments.—Abutments, as shown in figure 131, are piers designed to receive the inclined thrust from one or more arches; they are therefore made of greater weight than ordinary piers by increasing the height or by increasing the width in the direction of the thrust.

Arches.—An arch is an arrangement of wedge-shaped blocks built about the form of some curve, mutually supporting each other, and being supported at both ends by abutments or piers. They are designed to support the weight of a wall over an opening made in the latter. The important points to be observed in the construction of an arch are as follows :—

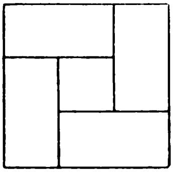


Fig. 127.

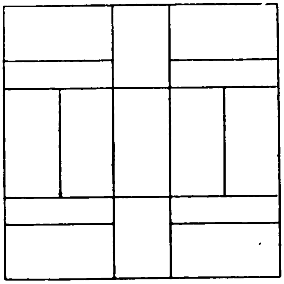


Fig. 128.

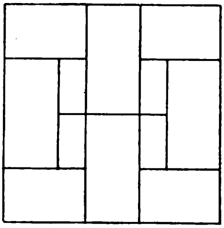


Fig. 129.

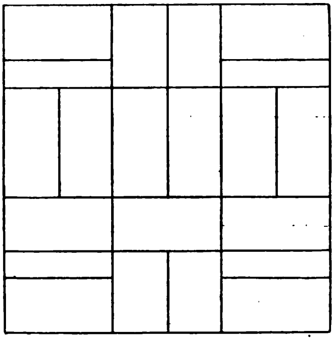


Fig. 130.

1st. Sufficient support and strength in the abutments to prevent the arch deflecting when loaded, and to safely resist overturning moment of the arch thrust.

2ndly. Depth enough in the arch to prevent the weight from above crippling it.

3rdly. Sufficient area in the pier and arch to prevent failure by crushing.

4thly. All bed joints should be perpendicular to the line of least resistance. In practice they are made normal to the curve of the arch, in which position they nearly approximate to normals of the line of least resistance. (See Article, *Advanced Course.*)

Technical Terms.—The following are the technical terms used in connection with arches:—

Voussoirs.—The courses of bricks or stones which compose the arch.

Springers.—The extreme or lowest voussoirs of arches.

Skewbacks.—The bricks forming the sloping abutments on which the extreme or lowest voussoirs rest, of flat or segmental arches.

Key.—The uppermost or central brick or stone of the arch.

Intrados or *Soffit.*—The under or concave side of the arch

Extrados or *Back.*—The upper or convex side.

Abutments.—The outside supports of an arcade (see preceding paragraph).

Piers.—The intermediate supports of an arcade (see preceding paragraph).

Capital.—The name given to the moulded or carved cornice of a column, as shown in figure 131.

Abacus.—The moulded slab crowning the capital of a column, and by which the arch or lintel is supported, as shown in figure 131.

Impost.—The upper part of a pier or abutment on which an arch rests or from which it springs, generally finished with a moulded cap, as shown in figure 131.

Arcade.—A series of arches carrying a wall, above, and supported by columns or piers, as shown in figure 131.

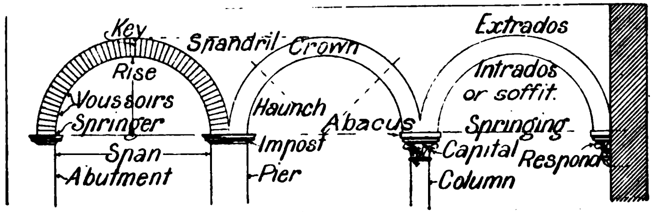


Fig. 131.

Arcade

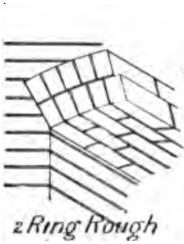


Fig. 132.

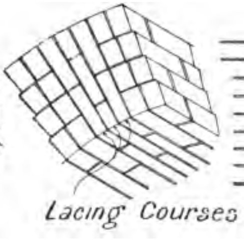


Fig. 133.

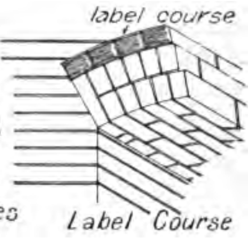


Fig. 134.

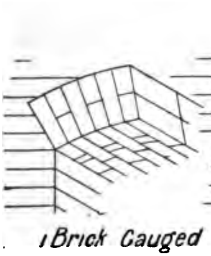


Fig. 135.

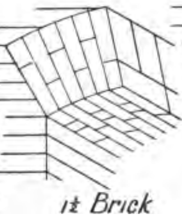


Fig. 136.

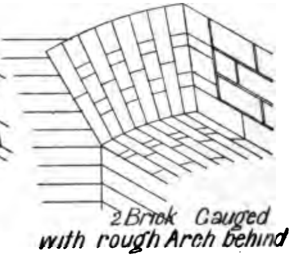


Fig. 137.

Respond.—The semi-column or corbel forming the support of the end arch of an arcade, usually projecting from a flank wall, as shown in figure 131.

Springing Points.—The points from which the curves of the arch commence, as seen in elevation.

Span.—The horizontal distance between the springing points.

Crown.—The highest point of extrados of arch.

Rise.—The vertical distance between the highest point of the soffit and the level of the imposts or springing points.

Haunch.—The name given to the lower half of the arch, from the springer or skewback, midway to the crown.

Spandril.—The irregular triangular space between two arches, or the space enclosed by vertical lines drawn from the springing of the extrados and the horizontal line tangent to the crown.

Ring Courses of Arches.—The name given to those courses of brickwork that partake of the circular form, as seen on the face of the wall. Figures 132 to 134 give examples of 4½″ rings, whilst figures 135 to 137 give examples of 9″, 14″, and 18″ rings respectively.

Lacing Courses.—The continuity of the ring courses of arches is sometimes broken by a bonding or lacing course, as shown in figure 133. The object of the lacing courses is to distribute the pressure more evenly over the sectional area of the arch.

Label Course.—The name given to a course of bricks laid flatwise on an arch and deepening it, as shown in figure 134. These courses usually project and are moulded and weathered on their upper surface to throw all rain water clear of the arch, and they are frequently made of a different colour to the arch to enhance the effect.

Arch Classification.—Arches may be either gauged, rough axed, or plain brick arches.

Gauged Arches.—These are used for the external faces of walls. They consist of soft bricks of a fine texture. The side joints are cut and rubbed on a stone to the required shape with sharp arrises, to form a fine joint, which when finished should not be more than $\frac{1}{32}$ of an inch thick. The voussoirs are usually jointed in lime putty to about $\frac{1}{2}''$ from the face, the back portion being scored out and grouted in portland cement.

The depth of flat arches varies to some multiple of the thickness of a brick, being rarely less than 9″.

In flat-gauged arches, as shown in figures 138 to 141, there is a camber of $\frac{1}{8}$ of an inch for every foot of span, to compensate for any settlement, and to prevent the appearance of sagging common to all horizontal lines. To obtain the centre from which the bed-joints are struck, the following rule is adopted:—Set out the top and bottom boundary of the arch, assuming it to be 1 foot in depth, and then mark on each extremity of the extrados 1½ inch for every foot in the clear span of the arch beyond the extremities of the intrados; by joining these points by a line the inclination of the skewbacks is obtained, and if the line be produced, the intersection gives the centre of the arch. The true depth of the arch may then be set out. It is necessary that there should be an odd number of bricks in an arch in order to obtain a key, and it is preferable that the odd number is such that the heading joints in springers and keys are at the same level, and these must be so struck that they can all be cut from one templet. To do this a curve must be struck from the centre found by the intersection of the skewbacks produced, tangent to the extrados of the arch, and the voussoirs must be divided out on this curve, as shown in figure 138.

Figures 142 to 144 show a segmental gauged arch with a discharging arch of concentric outline at the rear.

Outline of Arches.—The name by which an arch is known is generally that of the curve of which the arch is a segment.

The following figures (145 to 157) show the methods of

Fig. 138.

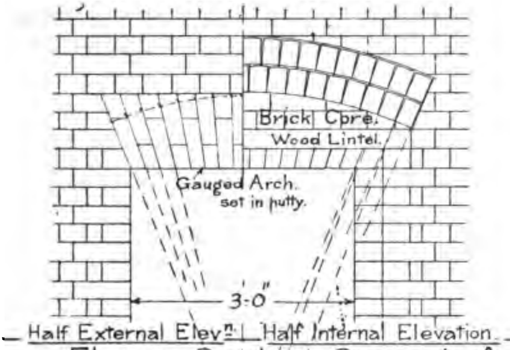
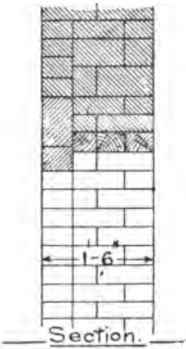


Fig. 139.



Flat or Camber Gauged Arch.

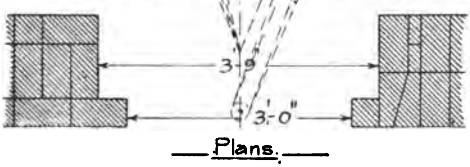


Fig. 140.

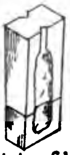


Fig. 141.

Sketch of Voussoir showing Grout Channel.

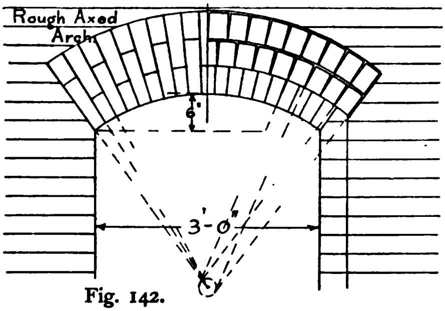


Fig. 142.

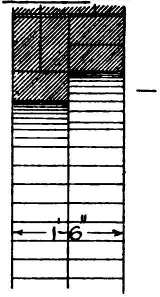


Fig. 143.

Segmental Arch.

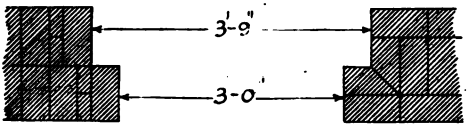


Fig. 144.

setting out the semi-circular, stilted, lancet, equilateral, drop, three-centred, four-centred, Venetian pointed, and Florentine forms of arches.

The setting out of the first seven is obvious. The depth of the arch at the springing in the Venetian pointed must be given, the curve of the extrados and heading joints subtend at their centres similar angles to that subtended by the arc of their intrados, as shown in figures 152 to 154. In the Florentine, as shown in figures 155 to 157, the intrados is a semi-circle, therefore the depth at the springing and crown must be given. The centre will be upon the springing line at the intersection of the bisecting line of the line joining the crown and the springing of the extrados or heading joints.

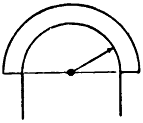


Fig. 145.

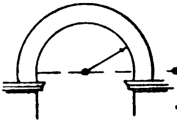


Fig. 146.

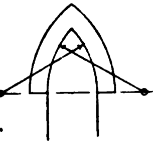


Fig. 147.

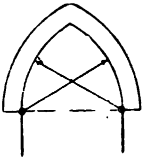


Fig. 148.

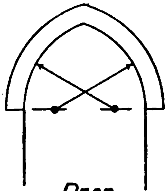


Fig. 149.

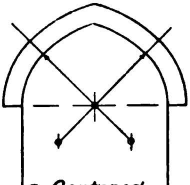


Fig. 150.

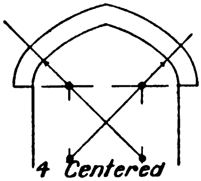


Fig. 151.

Elliptical Arches.—The curve of the ellipse is usually struck for most practical purposes by the trammel. This is inconvenient for arches owing to the amount of labour in determining the bed joints, which should be all normals to the ellipse; and, further, if this were done each voussoir would be of a different shape, thus requiring a separate templet for each voussoir. This may be avoided by striking a curve from three

Fig. 152.

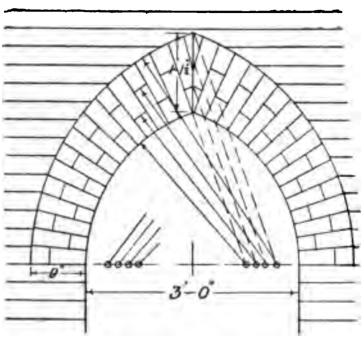


Fig. 153.

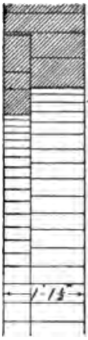
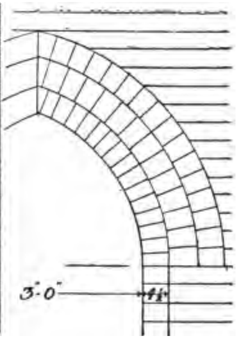


Fig. 154.



Front Elevation. Section. Back Elevation

Venetian Pointed.

Fig. 155.

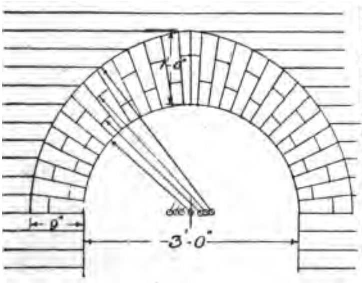


Fig. 156.

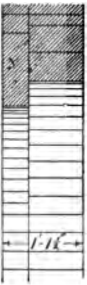
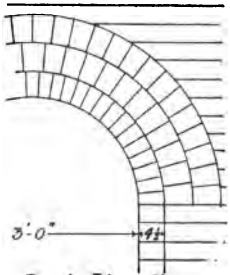


Fig. 157.



Front Elevation. Section. Back Elevation.

Florentine.

centres, as shown in figure 158, which can be made a very close approximation to a true ellipse, and requiring only three templets to cut the voussoirs. To strike the semi-arch, let a rectangle be described having for its sides the semi-major and semi-minor axes, divide the lines *a b* and *b c* each into three equal parts at points 1, 2; 3, and 4. From the points 3 and 4, draw lines to the point *d*, and from *e*, which is distant from *a* a length equal to *a d*, draw lines through points 1 and 2, the intersection of the lines drawn through 2 and 3 and 1 and 4 are points in the curve of a true ellipse. To find the first centre *c*, draw a line from *d* to 5 and bisect it, at the intersection of

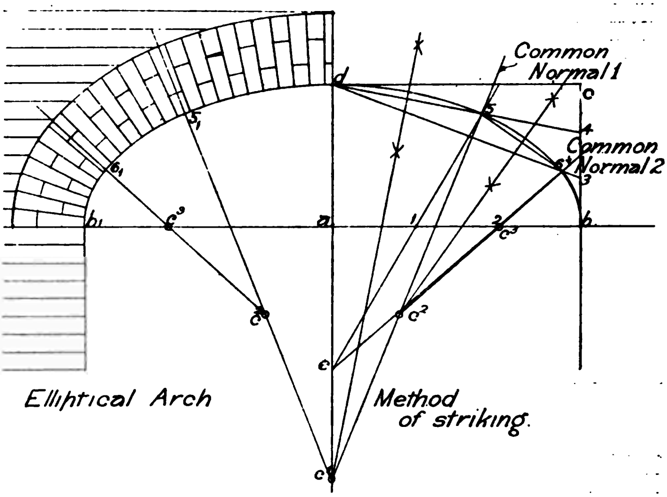


Fig. 158.

he bisecting line and the minor axis produced will be the first centre. Join c^1 and 5, this will be the common normal between the curves *d*.5 and 5.6, and must therefore contain centre No. 2, which may be found by bisecting a line joining 5 and 6 and producing till it cuts the common normal c^1 5. From c^2 draw a line through point 6, this will be the second common normal and will contain c^3. The intersection of common normal 2 with springing line will give the third centre. All the bed joints of the voussoirs are struck from the centres of the segments in which they are situated.

Fig. 159.

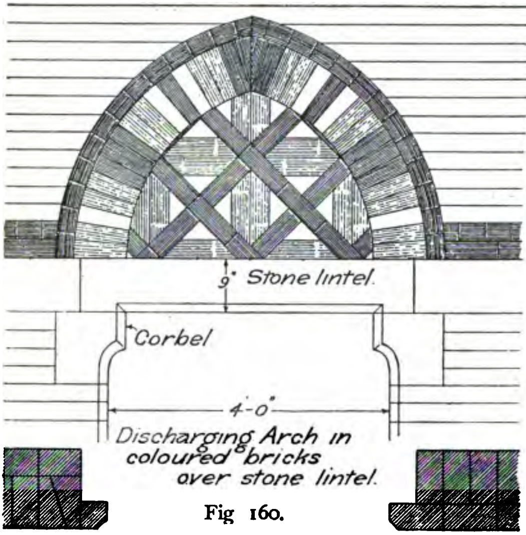


Fig 160.

Fig. 161.

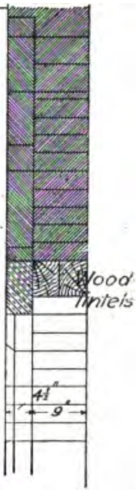


Fig. 162.

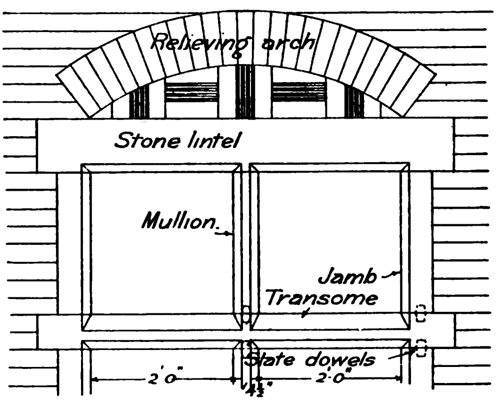
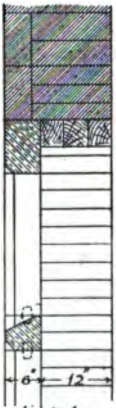


Fig. 163.



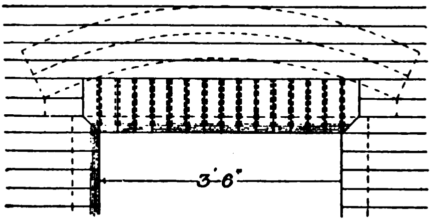
Relieving or Discharging arch over Stone lintel.

Figs. 159–163. Arches with Coloured Treatment.

Figures 159 to 161 show a gauged relieving arch treated by an ornamental arrangement of coloured bricks.

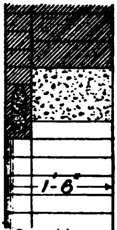
Figures 162 and 163 show a gauged relieving arch over a stone lintel. It is unnecessary for the relieving arch to spring from the extremities of the lintel, as in this case the lintel is of a material equally durable as the arch.

Flat Gauged Arch or *Joggled Lintel,* as shown in figures 164 and 165. This is employed in openings in glazed brickwork and where it would be difficult to cut the bricks to the necessary wedged form. The bed surfaces of the bricks are rubbed to obtain a thin joint, they are then built upon a turning piece and the frogs (of which there are two on each brick) filled with Portland cement grout, which forms a joggle.



Flat arch or Joggled Lintel.

Fig. 164.



Section.

Fig. 165.

It is unwise to use these in openings greater than 4 feet. Above that span the bricks should be perforated and an iron bolt passed through.

Rough Relieving or *Rough Discharging Arches* are usually formed by laying ordinary bricks on edge (without being cut or rubbed), on rough centres, or turning-pieces, or on a brick core shaped to the required curve, as in figure 138, or on a curved wood lintel, illustrated in figures 166 and 167. It will be seen that the joint is much wider on the extrados than on the intrados, as all the joints are V-shaped in elevation. If arches of this description were built in 9-inch rings this defect would be serious; consequently these arches should be constructed in 4½-inch rings, as shown in figure 166, which to a great measure reduces the imperfection. These are chiefly used for internal arches over doors and windows where they will be covered with plaster. A relieving arch is usually placed behind a gauged brick arch, to relieve the latter of the superincumbent load.

Fig. 166.

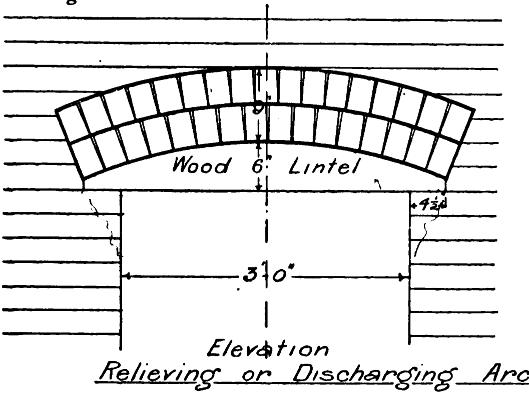


Fig. 167.

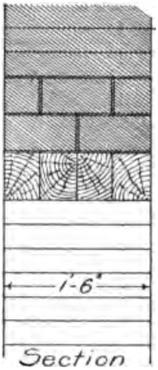


Fig. 168.

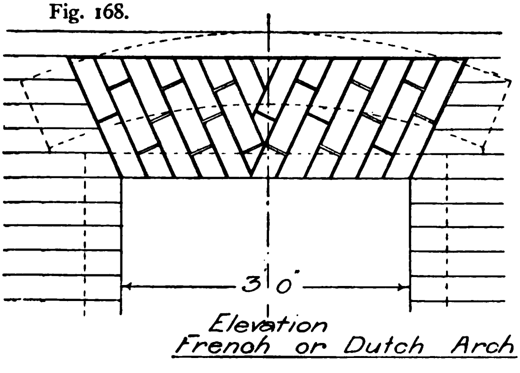


Fig. 169.

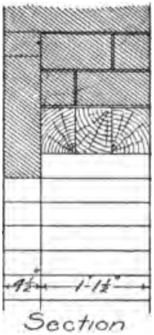
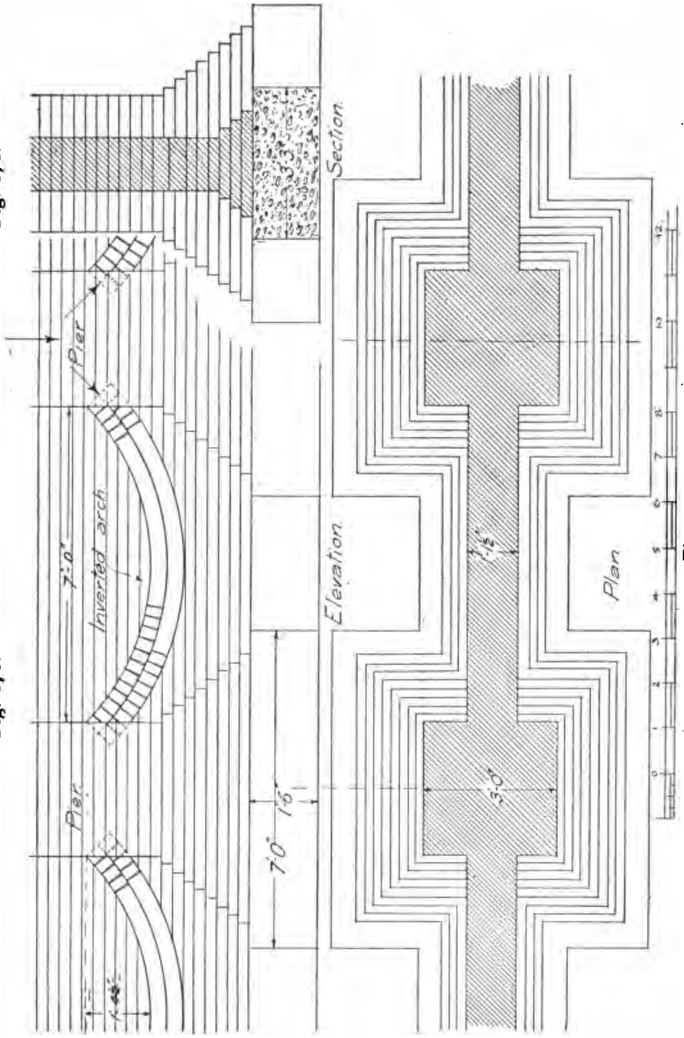


Fig. 171.

Fig. 170.

Fig. 172.



Figs. 170–2. Inverted Arches.

Inverted Arches.—These are rough arches inverted, springing from piers or abutments upon which the bulk of the weight is concentrated and with which there would be a possibility of unequal settlement with the remainder of the wall due to the ground under the foundation being subjected to a non-uniformly distributed stress. Their effect is to distribute the pressure uniformly along the whole length of the foundation. The minimum rise should be about one-fifth of the span, as illustrated in figures 170 to 172.

Dutch Arch.—Figures 168 and 169 show a rough brick arch, known as the French or Dutch arch, which is often used for external arches that are to be plastered over to avoid the expense of a flat gauged arch. It is only used in rough work, and is of weak construction.

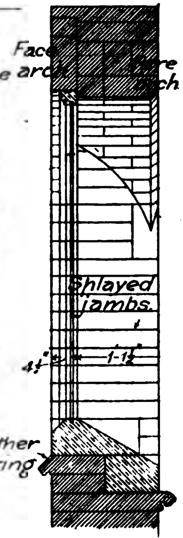
Trimmer Arches.—These are a form of rough arch adopted for supporting hearths in front of chimney breasts, and having an abutment against the trimmer or trimming joists, as shown in the chapter on floors.

Rough Axed Arches.—These arches are employed where it is required to have a strong arch of a neat appearance for the elevations of factories or warehouses, etc. The voussoirs are of the ordinary well-burnt facing brick, and are neatly cut with the bricklayer's axe to the required shape.

The roughly-cut surface forms a good key for the mortar and resists the sliding tendency of the voussoirs. The joints vary from $\frac{3}{16}$ths to $\frac{3}{8}$ths of an inch.

Pointed Arch with Rere-arch.—Figures 173 to 175 show an opening formed with splayed internal jambs, pointed arch, and stone cusps externally, and pointed barrel rere-arch internally, which is the method adopted in arcuated openings where splayed jambs are employed. The intersection of the rere-arch and splayed jambs shown in the figure 174, is obtained by drawing a number of vertical lines on the splayed jambs, shown in the internal elevation figure 173, and drawing these lines on the jamb in the sectional elevation and projecting from the internal elevation, the points of intersection of these vertical lines with the barrel arch, joining these projected points in the sectional elevation will give the curve in this projection.

Fig. 174.



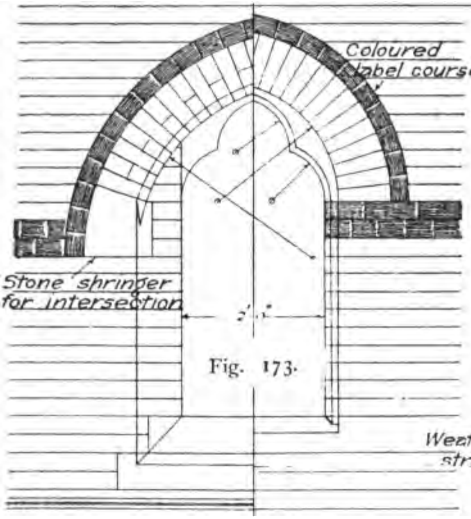


Fig. 173.

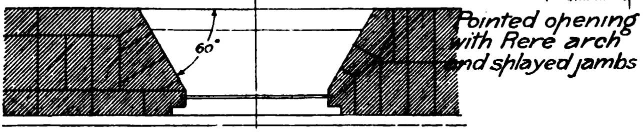


Fig. 175.

Arch Built with Orders.—This is another treatment of the arch when employed in the openings of very thick walls, where the arch consists of a number of rings similar to a rough arch. It is a common practice to diminish the width of each ring from the outer (which is generally in width the full thickness of the wall) to the inner ring, the width of which is very much smaller, thus forming a number of receding planes: each of these rectangular rims is termed an order. This relieves the opening of the clumsy and heavy appearance that is attendant upon a square opening in such a position ; it also

Fig. 176.

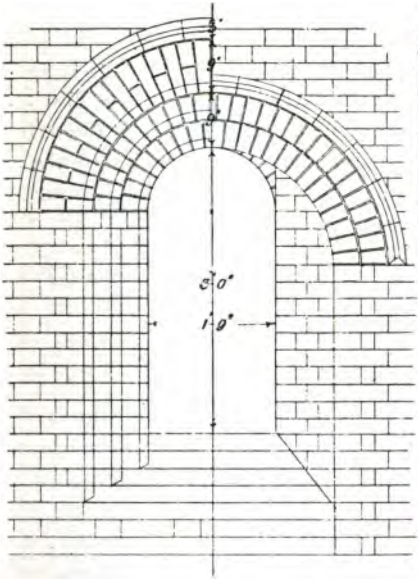
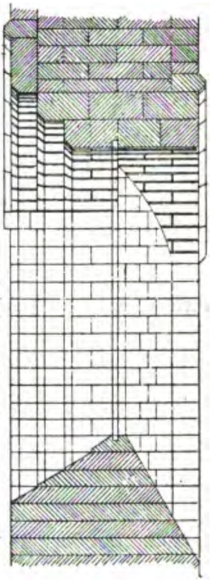


Fig. 177.



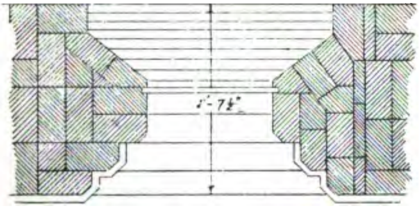


Fig. 178.

admits of the distribution of light inside to a much greater extent than is the case with a square opening. The jambs inside such an opening are usually splayed; the inner edge of the splay may be carried round the outer arch in a concentric curve or curves, or the inner arch may be an ordinary barrel arch, with its crown at or near the same height as that of the outer, and with the springing-line much lower, thus forming a curved line of intersection on the internal jambs and soffit. The edges of the external receding planes are often richly moulded. The orders may rest at the springing of the arch on the abaci of small collonettes, or they may be continued to the sill, as shown in figures 176 to 178.

Lintels.—These are horizontal members placed over square openings to form the head and support the work above; they may be of wood, iron, coke-breeze concrete, stone, or brick.

Wood Lintels.—These consist of pieces of timber from 4½ by 3 inches upwards, according to the span of the opening; they are generally assisted by a rough brick arch as a precautionary measure in the event of the timber being destroyed. The space between the lintel and the arch is filled with a brick core, see figure 138. The lintel sometimes has its upper surface curved, thus forming a turning piece for the arch, see figure 166.

Iron Girders.—These are generally used where the openings are very wide, and where there is no space for an arch above, as shown in the figure illustrating the shop front in the Advanced Course.

Coke-breeze Concrete.—This is formed of 4 parts by volume of coke-breeze to one of Portland cement, and is often employed, being to a certain extent fire-resisting and admitting of joinery being fixed to it, as it will hold nails and screws with great tenacity. These lintels are often curved on their upper edge, in which case they are relieved by an arch above, or they are made straight on their upper surface and their depth is increased. Where used for wide openings, tensional strength is obtained by embedding one wrought-iron bar for each half brick in the thickness of wall, supported by lintel ½ inch thick and having a depth of ½ inch for each foot of the span.

Stone Lintels.—Stone is unsuitable to withstand transverse stresses, and should never be used for openings above 3 feet in span unless relieved of the weight above by a discharging arch or save stones, as shown in figures 162, 163 and 268; otherwise, they would require to be abnormally deep.

Fixing Joinery to Brickwork.—The following materials are generally built in or inserted into brickwork to assist in the fixing of joinery thereto:—

Breeze Bricks.—These are frequently built into the jambs of openings and other parts of walls to which joinery is to be fixed for securing the backings, as the bricks admit of nails and screws being driven into them and hold to same with tenacity.

They have the advantage of not shrinking or perishing to the same extent as wood, but are inferior to wood in that nailed backings cannot be adjusted after having once been fixed. They are made of a similar thickness and width to ordinary bricks, and can be built in the walls in a similar manner.

Wood Bricks.—These are made of similar dimensions to ordinary bricks. They have been used to form a fixing surface in brickwork, but they are objectionable because they shrink, become loose and are liable to rot.

Wood Plugs are wedges cut on the twist. They are usually driven between the joints of brickwork to obtain a fixing for joiners' work, as shown in Part II., but are not to be recommended in jambs or edges of walls, as they are very likely to damage such parts.

Wood Joints.—These are lengths of wood, 4½ inches by ⅜ inch, built into walls at intervals, or wherever fixing is required. The wood practically does not shrink in thickness; it is the best mode of fixing in most situations, but has to be inserted while the brickwork is being carried up.

Levelling.—In bedding bricks, great care should be taken to keep all courses perfectly level. To do this, the footings and the starting course should be carefully levelled through, using a level at least 10 feet in length, commencing at one end and levelling towards the other, and taking care to reverse the level each time at each forward step, and completing the length to be levelled in an even number of steps. A piece of slate or iron is left projecting from the lowest course, and from this all other courses at the corners can be levelled by using the gauged rod, which is usually about 10 feet in length, with the courses marked on it. The work should then be again tested by the level, and the operation repeated.

Boning Method of Levelling.—This operation is used for the levelling of trenches, ground work, paving, etc. There are three rods in a set, two of these are levelled at a distance of about 10 feet apart; a third rod is then levelled at a similar distance, taking care to reverse the long level. The centre rod is then removed, and the level transmitted to any point along the line by sighting or boning over the first and third rods.

Figure 179 shows the method of using boning rods and setting a kerb-stone.

Paving.—External areas in towns, or about houses where not required for garden purposes, are usually covered with some form of stone or brick to give a hard surface to walk upon and to facilitate drainage. The following materials and methods are employed, brick, stone or concrete slabs, concrete slabs formed *in situ*, tar paving, asphalting, tiling and mosaic. Bricks for paving should be hard, well burnt and wear with a rough surface. Specially hard bricks, chequered on surface to afford a firm foothold, are manufactured for use in stables and similar positions. Bricks may be laid flat or on edge. Where laid flat, the area is usually covered with 6 inches of concrete, the bricks being then bedded on this in lime or cement mortar; where laid on edge, the ground is either concreted as before, or the surface of earth is levelled and the bricks are bedded in sand, the side joints of the bricks being then filled up with lime or cement grouting.

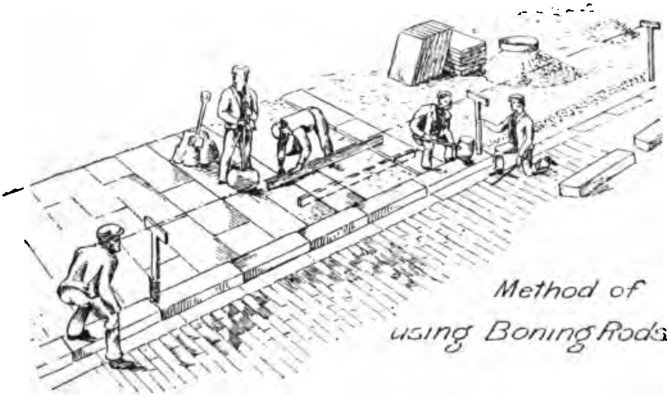

Method of using Boning Rods

Fig. 179.

Stone or Concrete Slabs.—Slabs of highly stratified stone that can be easily rent into approximately uniform thicknesses, tooled on surface, squared on edges, are largely used for paving. The method of laying is as follows. The ground is first levelled, and the surface covered with sand or sifted earth; the stones are then laid, being bedded in lime mortar about their edges. They are punned to their requisite levels with a tool known as a beedle, which also consolidates them upon their bed. Figure 179 illustrates the laying of stone paving. Concrete slabs have of late years been largely used for paving; they have the advantage of being cast in uniform superficial dimensions and thicknesses, which presents a uniformity in the appearance of the joints upon completion which greatly enhances the appearance. To obtain a similar effect in stone would be expensive, due to the waste in cutting.

Concrete Paving in Situ.—This method is largely adopted, in preference to the slab method, on account of the uniformity of the pavement and the fewness of the joints, which renders them clean and sanitary. They are usually formed in sections about 6 feet square. About 3 inches of coarse concrete is first deposited over section, and finished with about ¾ inch of fine stuff floated to the correct levels. While the surface is still soft, a metal roller is passed over it, producing a chequered face. The disadvantage of forming large concrete pavements is, that if any part settles and cracks the fracture is likely to star and spread in all directions. This effect is minimised by the formation of sheets not larger than 6 feet square, any damage being localised within this area.

Tar Paving.—The material is composed of limestone and coal tar. The paving is formed with a bottom layer equal to one-half of the whole thickness of paving, broken to pass through a sieve with a mesh of 1½ inch, a middle layer equal to one-fourth of the whole thickness of paving, broken to pass through a ¾-inch mesh sieve, and the remaining one-fourth broken to pass through a sieve with a ½-inch mesh. The compound is spread over the site by means of an iron rake, and is finished by being well rolled to an even surface. The compound is in the proportion of 12 gallons of coal tar to a cubic yard of broken limestone. Pitch is frequently added, to thicken the coal tar. The limestone and tar are heated before being mixed. Before being rolled, finely divided limestone, sand or grit is thrown over the surface and rolled into it whilst still soft. The total thickness of tar paving by this method varies from 2½ to 4 inches. Another method is to lay a coat of tar paving 1½ inch thick, composed of fine particles, upon a prepared surface of concrete 6 inches thick.

Asphalte Paving.—The various methods of asphalte paving are fully dealt with in my "Advanced Course."

Tile Paving.—These are thin slabs of finely prepared and well-burnt clay. They are manufactured in various colours and shapes up to about 12 inches square. The area to be tiled is covered with a bed of 6 inches of concrete; it is then floated with a coat about ¾ inch thick, composed of one of cement and one of sand screeded to an even surface. The tiles are then placed in position and pressed into the cement bed, the latter oozing up between the side joints.

Mosaic Paving.—There are two varieties of mosaic paving, Roman and Venetian. In both it is necessary to have a prepared ground of 6 inches of good concrete, on which a coat of ¾ inch of neat cement is floated.

The Roman variety consists of pressing into this floating coat small approximate cubes of marble of various colours about ¾ inch length of side. These may be arranged in various patterns. Pictorial designs are frequently worked. The design is first worked and coloured on paper, the stones required are selected, fitted and stuck on to the drawing, the whole pattern is then placed in position, stones lowermost on the pepared bed of cement. When the cement floating coat has set, the paper is damped and removed; the small cubes forming the ground colours are then bedded singly up to the design, when the whole surface is covered, and the face is levelled by rubbing with a stone and finishing by polishing.

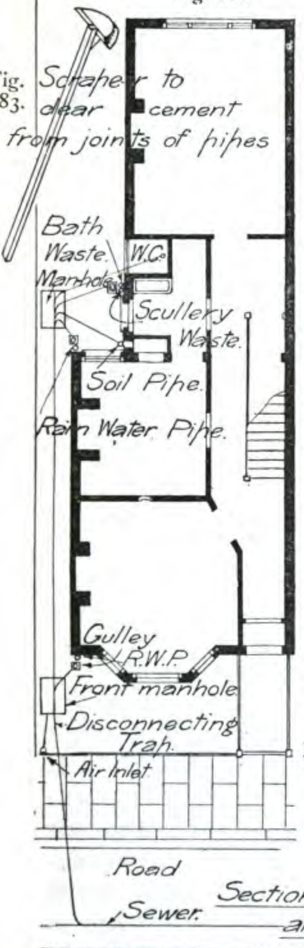
The Venetian variety is carried out by sprinkling small irregularly shaped chips of marble on to the floating coat of cement previously described; these are pressed into the surface with a hand float, and the whole is consolidated by rolling with a heavy iron roller. Patterns in various designs may be formed in this method by first cutting out the design in wood, and bedding the pieces of the latter in position. The ground work is then bedded about the patterns, and when set, the wood patterns are removed and the voids filled with cement coloured with pigments and with chips of different coloured marbles pressed in as described. The whole is then levelled and polished as in the Roman variety.

In floors composed of steel and concrete the rigid surface formed by the mosaic is subject to cracking, owing to the expansion and contraction of the joists. The ill effect of this is minimised by arranging the floor in sections, so that border lines, and consequently natural joints, are formed along the lines in which the variable expansion takes place.

House Drains.—The sewage and refuse fluid matter of domestic buildings is conveyed from water-closets, baths, sinks, etc., by means of pipes to a cesspool or to a main sewer. It is desirable to dispose of this matter in such a manner that any objectionable odours are reduced to a minimum and without contaminating any adjacent work or soil. Impervious stoneware or cast-iron pipes and well water-sealed traps are used. It is desirable that all lengths of pipes should be laid straight, with an inspection chamber at each of the horizontal angles or bends to permit of easy access in case of the stoppage of the drain. The various discharging pipes of the sanitary system of a building should as far as possible be collected at a manhole, as shown in figure 180, and not joined up at any other part of the underground system. Between the system of house drains and the sewer or cesspool into which it discharges there should be a disconnecting trap, as shown in figures 180 and 185, with an effective water seal to prevent the return of any noxious gases. All soil pipes should be taken direct to a manhole without traps, and should be continued at their upper ends above the highest window in the house, in order that they may serve as ventilators to the drainage

Fig. 180.

Fig. 183.



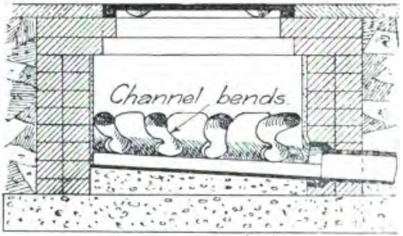


Fig. 181.

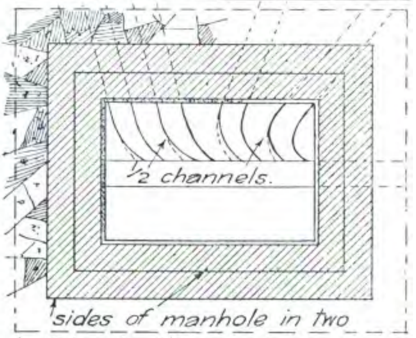


Fig. 182.

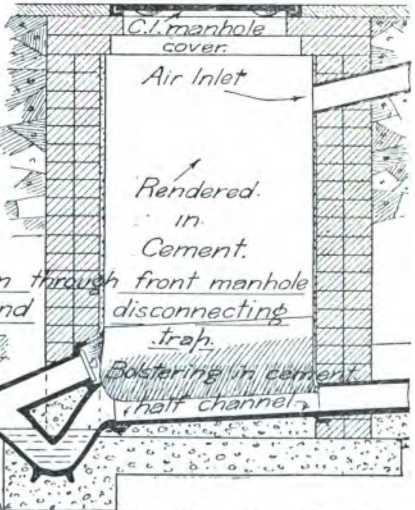


Fig. 185.

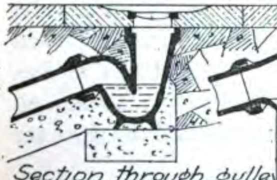
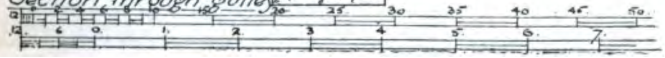


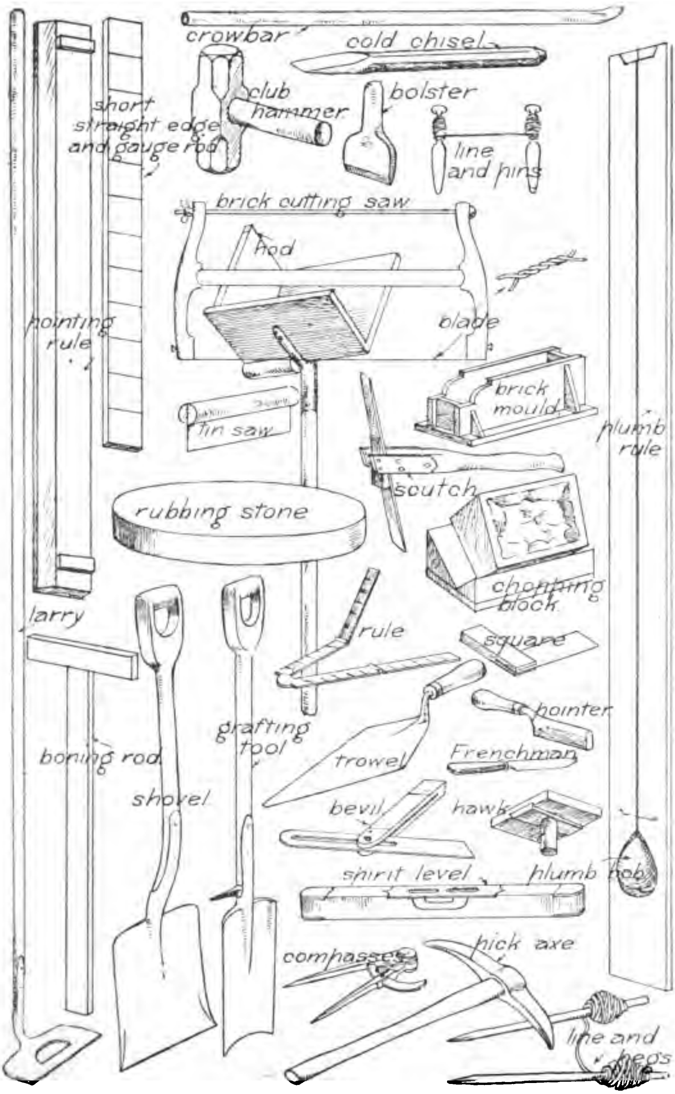
Fig. 184.



system on the house side of the disconnecting traps. A diagram of the complete system is given in the chapter on sanitation (Part II.). All other waste pipes should discharge over an open trapped gulley in order that all such pipes may be flushed with air other than that from the drain. The laying of the drains, if of stoneware, is usually executed by the bricklayer. The following would be the method adopted for a small terrace house, as shown on plan figure 180. All other systems would be laid on similar principles modified to comply with the peculiar conditions.

In the case of a terrace house, the drains should be laid after the building has been erected and has had time to settle.

The drains should be set out, the trenches cut to the true gradients, and the earth for manholes removed, the bottoms of the trench and the manholes are then covered with 6 inches of good concrete, the disconnecting trap should then be embedded and connected with the sewage system; the channels in the lower manhole should then be bedded, and the straight portion of the pipe between the two manholes laid so as to terminate with the channel in the upper manhole; the various branch connections are then made, commencing in the cases of sinks, bath waste and rain water pipes, with a gulley trap, which disconnects the drain from the outer air and terminates in a channel bend curved sufficiently to direct any discharge in the direction of the flow of the main drain. Branches connected with soil pipes are not trapped, but the soil pipe is continued as before stated so as to act as a vent. The manholes are then built, the walls of which are 9 inches thick built in two separate half-brick thicknesses in cement mortar to render them less pervious. The spaces between all channels in manholes are bolstered to a height of at least 4 inches and rendered in cement, with a trowelled surface together with the sides of the manhole. The drains at this stage should be tested, and, if found satisfactory, should be backed up with concrete to half their height; or, if the pipes are



Figs. 186–212. Bricklayer's Tools

laid under a house they should be completely enveloped in concrete for a thickness of 6 inches all round the pipe. The ground may then be filled in and punned.

Stoneware pipes are slightly curved in their length; the deviation from the straight should be arranged to lie in the plane of the gradient to prevent an irregular gradient.

The pipes are usually jointed in neat cement; this should be properly cooled but not "killed," that is, mixed up after the initial set has commenced, and then used. Before bedding the pipe, the socket of the preceding pipe should have a layer of cement bedded around it; the spigot end of the next pipe is then inserted, and care taken to pack it perfectly concentric with the preceding pipe. Neat cement should then be tucked in and pressed home in the joint with a piece of wood cut for that purpose, to ensure the joint being quite solid. The joint is then flushed with cement. On inserting the pipe a large amount of the cement first bedded will ooze out into the interior of the pipe; this should be carefully scraped out each time a joint is made, with the tool shown in figure 183, to prevent any projections on the inside of the pipe.

Excavator's and Labourer's Tools.—The following tools as shown in figures 186 to 215 are used by the excavator and labourer: 1, the pick for breaking up hard ground; 2, the grafting-tool for digging out earth such as stiff clay; 3, the shovel for lifting earth; 4, the line and pegs, for outlining trenches; 5, the boning rods for levelling; 6, the level, which consists of a spirit-level mounted in a straight-edge at least ten feet in length; 7, the hod, this consists of three sides of a rectangular box mounted on a staff, and used for carrying bricks and mortar, and capable of carrying 12 bricks, or about ⅔ of a bushel of mortar; 8, the larry, which is a steel blade bent at right angles, and fixed to a long handle and used for the mixing of mortar; 9, the beedle is a large wood mallet with a circular pine head, with rounded ends about 18 inches and 15 inches in diameter, with a handle about 3 feet long. It is used by the pavior for punning paving stones into their position when bedding, as shown in figure 213; 10, the rammers are of two kinds—1st, that used for ramming granite sets in roadways, and consists of a cylindrical piece of wood about 3 feet 6 inches long, with a vertical handle at top and a horizontal handle about half-way up, as shown in figure 214; 2nd, that used for the bottoms of trenches and for consolidating ground. They are of the shape shown in figure 215,

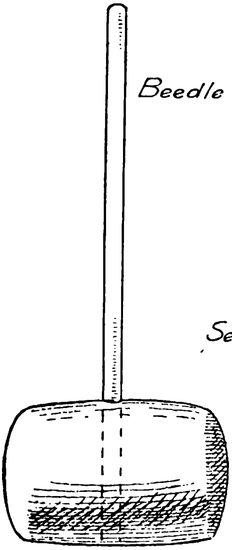


Fig. 213.

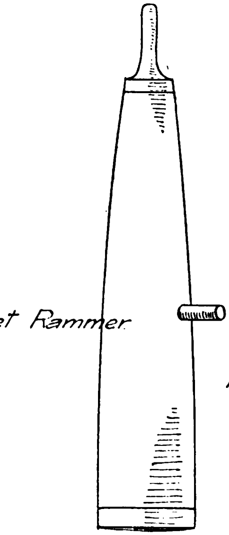


Fig. 214.

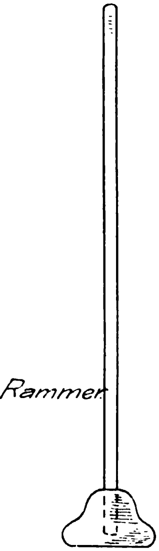


Fig. 215.

the head being of iron and about 10 lbs. in weight; the handle is of ash about 10 feet long.

Bricklaying Tools.—1, large trowel used for the spreading of mortar and the bedding of bricks; 2, the 2-feet rule; 3, the plumb-rule and bob for the carrying up of walls perpendicularly; 4, the short straight-edge about 3-feet in length, with the brick courses marked on it for the building up of corners; 5, the spirit-level for testing the horizontality of work; 6, line and pins for building the portions of walls straight between corners.

Brick-Cutting Tools.—Rough cutting: 1, the large trowel; 2, the club hammer and bolster, for cutting with greater exactitude than with the trowel; 3, the cold chisel for the cutting of chases and for general work.

Fair cutting, *Hard Bricks:* 1, the tin saw for making an incision $\frac{1}{8}$ of an inch deep, preparatory to cutting with bolster; 2, the chopping-block, which is an arrangement of two blocks of wood so fixed as to support a brick in an angular position convenient for cutting; 3, the scutch consists of a stock and a blade, the latter generally formed of a flat file about 10 by 1 inches, sharpened at both ends and fixed in the stock by means of a wedge. This displaces, and is an improvement on the old brick-axe, as the blade can be removed and sharpened readily; it is used to hack away the rough portions on the side of a brick after the edges have been cut by the tin saw and bolster.

Fair cutting, *Soft Bricks:* 1, the saw, consists of a frame holding the blade, which consists of twisted soft steel or malleable iron wire, No. 16 B.W.G., and is used for cutting soft rubbing bricks; 2, the rubbing-stone, is a circular slab of gritty York stone 20" diameter, for rubbing the faces of bricks to a true surface; 3, the mould is a wood box enclosing bricks that are to be cut to a shape, the sides of the box being formed to that shape, and the edge over which the saw-blade works is protected by a strip of zinc; 4, the square, bevil, and compasses are used in the setting out of work.

Pointing Tools.—1, Small trowels for filling up joints of new brickwork; 2, the pointing rule, which is a feather-edged straight-edge, with two small pieces $\frac{3}{8}$" thick nailed at each end to keep the rule away from the wall and allow the trimmings to fall through; 3, the frenchman for trimming joints consists usually of an old table-knife, with the end ground and turned up, as shown in plate containing figures 186 to 212; 4, the jointer, used for tuck pointing in old work.

CHAPTER III.

MASONRY.

Definition.—Masonry is the art of building in stone in a similar manner to that of brick, with the exception that brickwork is carried out with uniform-sized blocks, thus admitting of a number of definite systems of laying the bricks; whereas in stone, owing to the expense in working the material, the face stones only are squared, and the interior or hearting is filled up with smaller stones roughly fitted with a hammer. The stones are in the great majority of cases of varying dimensions, thereby making it a matter of great skill to obtain a proper bond in the work; and owing to the irregular shape of the material the walls have to be made considerably thicker than walls of the same height in brick, with the exception where the walls are built of coursed stones properly squared, in which case the thickness may be even less than that of brick walls.

The great dimensions in which stone may be obtained, lends itself to a much greater degree than bricks for buildings of architectural pretensions, rendering it possible to have cornices and corbelled work of great projection which is impossible in brickwork.

Technical Terms.—The following is a list, and also an explanation, of the labours in stonework :—

Bond, Lap and Course.—These terms have the same meaning as given under brickwork.

Through Stones. Stones which extend through the entire thickness of wall, to tie or bond it. These are considered objectionable, for the reason that if any projection has to be taken off at the back, to present a fair face, it would disturb the setting of the adjoining masonry, and damp is more likely to show on the interior of walls where the continuity of the material is uninterrupted.

Headers.—The name applied to stones, the lengths of which are ⅔ to ¾ thickness of wall, and are laid across it.

Bonders.—These may be either "throughs" or "headers."

Grout.—This is a thin mortar, which is poured over the stones when brought up to a level surface, to fill up any interstices between the stones in the hearting of walls or other positions as necessity requires.

Spalls or Shivers.—These are broken chips of stone, worked off in the dressing.

Weathering.—The top face of a stone worked to a plane surface inclined to the horizontal for the purpose of throwing off the water is said to be weathered, as in sills, cornices, etc.

Footings.—The object of footings is the same as in brick walls. Stone footings should be large rectangular through stone blocks. Square stones in plan are not so good as oblong. All stones in the same course must be of the same height, but all courses need not necessarily be of the same depth. The breadth of set-offs need not exceed 3 or 4 inches.

If the expense of stone is an objection, footings may be made of bricks or deep beds of concrete, as already described in the chapter on brickwork.

Bed Surface.—The bed surface must be worked in one plane surface. Masons to form thin joints often make the beds hollow. This is bad, as it is liable to spall; all the pressure will be thrown on the outer part, which is liable to spall the edge of the stone.

Galleting.—The term given when sharp bits of flint, or pebbles, which are pressed into the face joints of rubble walls to preserve the mortar and to give a pleasing effect, as shown in figure 253.

Dressings.—Stones are said to be dressed when their faces are brought to a fair surface; but any stones which are cut or prepared and are used as finishings to quoins, window and door openings, and may be applied as an ornamental feature, such as quoin stones, window and door jambs, as shown in figure 336, are described as dressings.

Quoins.—In rubble and inferior stone walls, quoins are built of good blocks of ashlar stone to give strength to the wall. These are sometimes worked to give a pleasing effect, and where hammer dressed and chamfered, as in figure 266, are said to be rusticated. They are, at times, merely built with a rough or quarry face, as in elevation figure 263, only having the four face edges of each stone lying in one plane.

Window and Door Jambs.—For purposes of strength these should be of cut stone, attention being given that each course is securely bonded. For that reason it would not be advisable to build them of rubble. Figures 313 to 315 show alternate courses, one showing the stones forming the window jambs acting as stretchers—these are termed outbands, as shown in figure 323; and the other a through stone or header forming the face of reveal and the face of rebated jamb, and is termed an inband, as shown in figure 323.

Scontions.—The stones forming the inside angle of the jamb of a door or window opening, as shown in figure 327. These are often cast in concrete to effect a saving in labour.

Sills.—These are the lower horizontal members of openings, and those in stone are usually of one length, being pinned in cement to both sides of the opening. They should be fixed after the carcase of a building has been finished, and any settlement that was likely to occur through a number of wet mortar joints has taken place. They may be plain and square, as for door-sills, or sunk, weathered, moulded with drip and with properly formed stools and grooved for metal water bar, or sunk, weathered, throated and grooved for metal water-bar, all as illustrated in chapter on joinery; or moulded, grooved and weathered, as shown in figures 325 to 327.

Corbel.—A piece of stone projecting from a wall to support a projecting feature. Figures 221 to 223 show methods of supporting a projecting angle of a building by means of corbels.

Skew Corbel.—As shown in figure 225, is a projecting stone at the lowest part of the triangular portion of the gable end of a wall supporting the starting piece of coping, and resisting the sliding tendency of the latter. The skew corbels are often tied in to the wall by long iron cramps.

Kneeler.—This is a long stone, tailing well into the gable wall, as shown in figure 225, and resists the sliding tendency of the coping.

Saddle or Apex Stone.—Highest stone of a gable end cut to form the termination of two adjacent inclined surfaces, as shown in figure 225.

Lacing Course.—Owing to the absence of bond in flint walls, courses of bricks, three deep, are inserted at intervals, to give strength to the wall and bring it to a level surface, as shown in figures 254 and 255. Sometimes the name is applied to a horizontal band of stone placed in rubble or flint walls to form a longitudinal tie.

String Courses.—Horizontal projecting bands of stone, as in figures 266 and 267, often carried below windows, and are of architectural importance, imparting a feature to the building.

Plinth.—A horizontal projecting course or courses built at the base of a wall, as in figures 266 and 267.

Cornices.—The moulded course of masonry crowning buildings, generally having a large projection, as shown in figures 266 and 267, to throw off the rain.

Blocking Course.—A course of stones erected to make a termination to the cornice (see figures 266 and 267), the object being to gain extra weight to tail down the cornice, and to form a parapet.

Copings.—The highest and covering course of masonry, forming a waterproof top, to preserve the interior of wall from wet, which in frosty weather might burst the wall. Figures 224 and 225 show copings flat on the top surface, which should be used only for inclined surfaces, as on a gable or in sheltered positions. Figures 251 and 252 give section and elevation of feather-edged copings, which throw water off on one side of walls, and are necessary for parapet walls of crowded thoroughfares. Saddle-back is the name applied when the upper surface is weathered both ways, as in figures 259 and 262; and segmental, when the section of coping shows the upper surface to be a part of a circle, as in figures 256 and 257.

Throatings.—Grooves on the under surfaces of copings, sills, string courses, etc., acting as drips for any water that would otherwise trickle down, and disfigure the walls, as in section, figure 259.

Templates.—Pieces of stone placed under the end of a beam or girder to distribute the weight over a greater area, as in figures 383 and 384.

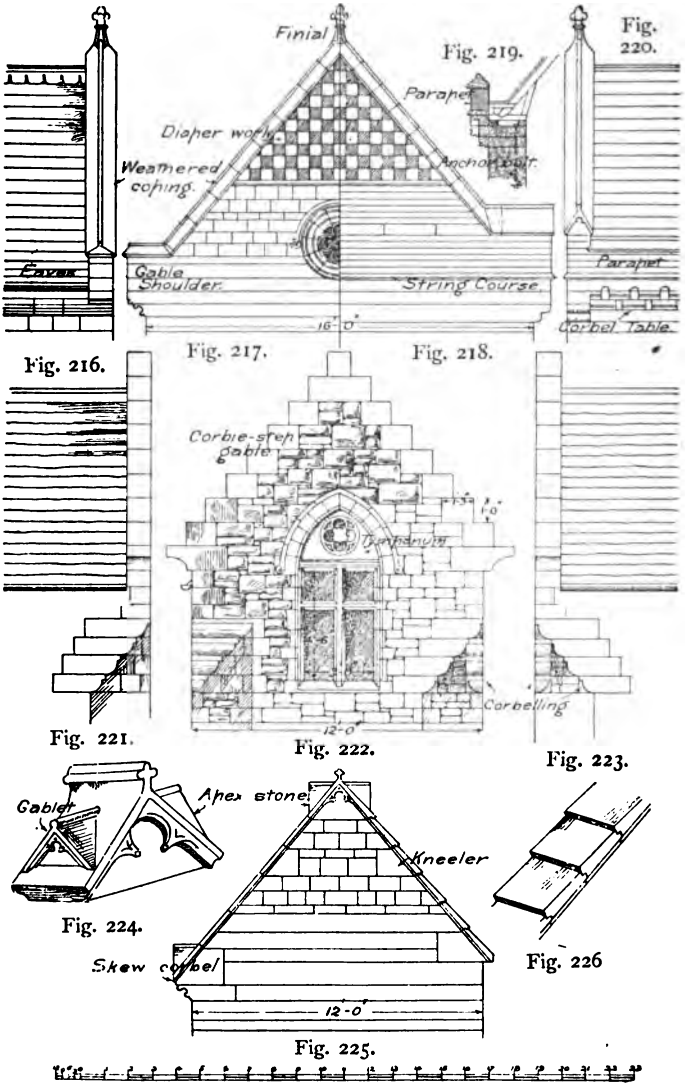


Fig. 216. Fig. 217. Fig. 218. Fig. 219. Fig. 220. Fig. 221. Fig. 222. Fig. 223. Fig. 224. Fig. 225. Fig. 226

Figs. 216—226. Finishings of Gables.

Gable Details.—The tops of stone walls are protected by coping, and these, where placed on steep gables, need support at their lower ends and at intervals; this may be done by constructing a shoulder at the foot as shown in figures 217 and 218, or by the use of skew corbels as shown in figure 225; the intermediate supports are obtained by kneelers, which consist of stones having a part worked as a coping, the remainder tailing well into the wall, as shown in figure 225.

Corbie Step Gables.—A common method of finishing gables is by constructing a number of steps formed of some hard stone squared, the top surfaces being slightly weathered, as shown in figures 221 and 223, and known as corbie or crow-step gabling.

Gablets.—Many skew corbels are constructed with a small gablet as shown in figure 224, which gives extra weight to the skew corbel, thus rendering it more efficient for resisting the outward thrust of the coping stones. The apex stones are often treated in a similar manner.

Corbel-table.—A system of corbelling supporting a parapet, and often forming an architectural feature, as shown in figure 220.

Finial.—The aspiring ornament of an apex stone, and often richly foliated, as shown in figures 216 to 218.

Parapet.—The fence wall in front of the gutter at the eaves of a roof, as shown in figure 219. The castellated parapet is formed by a number of embrasures similar to the parapets used in ancient military buildings, as shown in figure 227, and much used in the later Gothic work as an ornamental feature.

Diaper Work.—Is the name given to bands, surfaces and panels in the stone work formed by square stones and similar squares, filled in with brick or flint work, giving a chequered

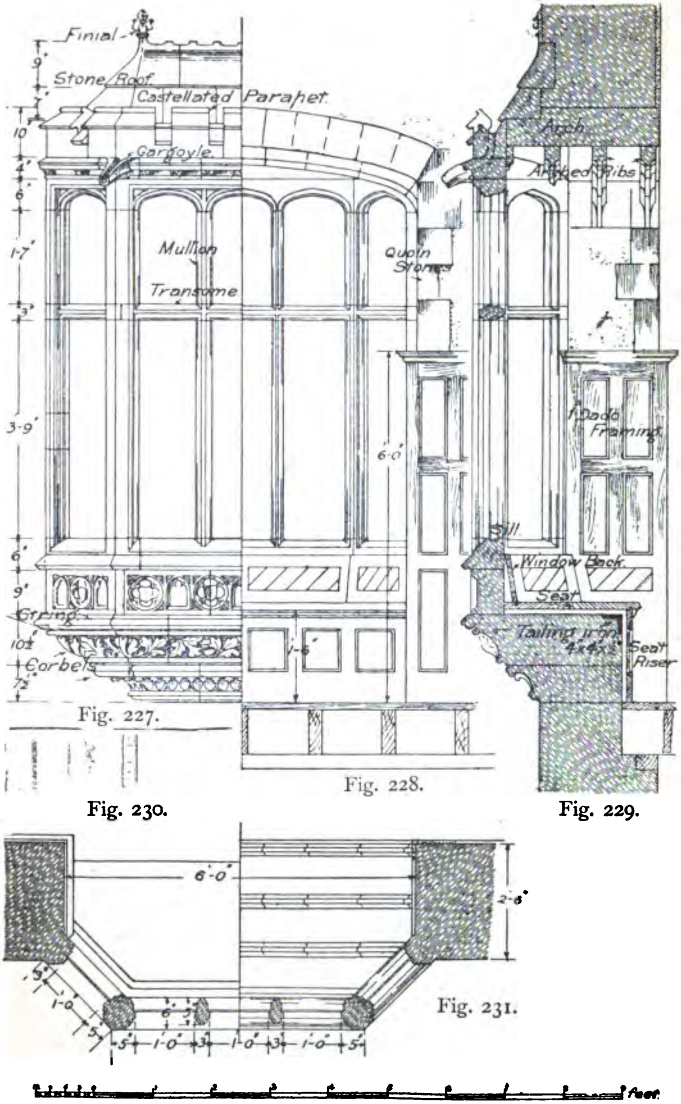


Fig. 227.

Fig. 228.

Fig. 230.

Fig. 229.

Fig. 231.

Figs. 227–231. Example of an Oriel Window.

appearance, as shown in figures 217 and 218. The term is also applied to any ornament arranged in squares upon the surface of ashlar masonry.

Tympanum.—The masonry filling in between the relieving arch and the head of a door or window. This is often taken advantage of to form a ground for carved ornament, as shown in figure 222.

Gargoyle.—Is a stone water-spout, as shown in figure 227, employed in buildings of Gothic character to carry off the rain from the gutters. These project sufficiently far to throw the water clear of the building. At present down pipes are employed, but the gargoyle is often retained as an overflow in lieu of a warning pipe.

Tailing Irons.—These are formed of H, L or T irons for holding down the ends of corbels in oriel windows, as shown in figure 229.

Stone Roof.—Figures 227, 229, show the method of arranging the stone roof over an oriel window. Figure 232 shows the method of forming a stone-covered roof over a vaulted chamber, such as was frequently used during mediæval times in military and monumental buildings. It is formed of stone flags bedded on rubble filling over the vault. In these roofs the flags are laid in two systems: in the first the flags are spaced apart, in the second the flags are bedded with a lap of 2 or 3 inches over the top edges of the flags in the first system. The whole upper surface has a slight fall for drainage.

Labours.—The following are the chief labours adopted in preparing stonework:—Sawing, plain work, boasted, tooled, combed or dragged, vermiculated, pointed, moulded, sunk, and rubbed, which may be either straight or curved work; scabbling, hammer-dressed, and chisel-draughted margins.

Half sawing.—The surface left by the saw. Half the cost of the sawing being charged to each part of the separated stone.

Self-Faced.—The term applied to the quarry face, or the surface formed when the stone is detached from the mass in the quarry; also the surfaces formed when a stone is split in two.

Scabbling or Scappling.—That is, taking off the irregular angles of stone; is usually done at the quarry, and is then said to be quarry pitched, hammer faced, or hammer blocked; when used with such faces the stone is called rock or rustic work.

Hammer Dressing.—Roughest description of work after scabbling, as shown in figure 236.

Chisel Draughted Margin.—To ensure good-fitting joints in hammer-faced stones, a smooth surface about an inch wide is cut with a chisel, forming a margin on the face of stone, as in figure 237.

Plain Work.—This is divided, for purposes of valuation, into half plain and plain work. The former term is used when the surface of the stone has been brought to an approximately true surface, either by the saw or with the chisel. Plain work is the term adopted for surfaces that have been taken accurately out of winding with the chisel. These labours are usually placed upon the bed and side joints of stones in walling.

Rubbed Work.—This labour consists in rubbing the surfaces of stones until perfectly regular, and as smooth as possible. The work is accomplished by rubbing a piece of stone with a second piece. During the first stages of the process, water and sand are added, gradually reducing the quantity of sand up to the finish. Large quantities of stone are rubbed by means of large revolving iron discs, on which the stones are placed, and kept from revolving with the disc by means of

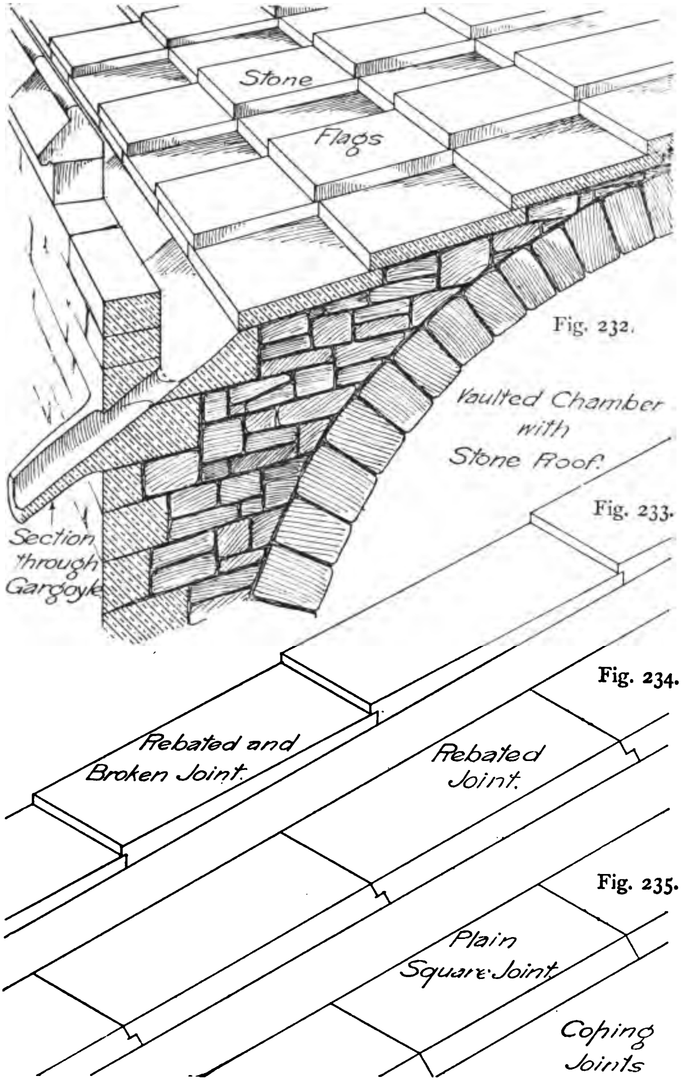


Fig. 232.

Fig. 233.

Fig. 234.

Fig. 235.

stationary timbers fixed across the table a few inches above the same. Water and sand are added to accelerate the process. Only plane surfaces can be rubbed in this way.

Polishing.—Marbles and granites, after the rubbed operation, are brought to a still smoother surface by being well rubbed with flannel and a paste of bees'-wax and turpentine or putty.

Boasted or Droved Work.—This consists in making a number of parallel chisel marks across the surface of the stone by means of a chisel, termed a boaster, which has an edge about 2½" in width. In this labour, the chisel marks are not kept in continuous rows across the whole width of the stone, as shown in figure 238.

Tooled Work.—This labour is a superior form of the above, care being taken to keep the chisel marks in continuous lines across the width of the stone, as shown in figure 239. The object of this and the preceding is to increase the effect of large plane surfaces by adding a number of shadows and high lights.

Furrowed Work.—This labour, used to emphasise quoins, consists in sinking a draft about the four sides of the face of a stone, leaving the central portion projecting about ⅜", in which a number of vertical grooves about ⅜" wide are sunk, as shown in figure 241.

Combed or Dragged Work.—This is a labour employed to work off all irregularities on the surfaces of soft stones. The drag or comb is the implement used, and consists of a piece of steel with a number of teeth like those of a saw. This is drawn over the surface of the stone in all directions, making it approximately smooth, as shown in figure 240.

Vermiculated Work.—This labour is placed chiefly on quoin stones to give effect. The process is as follows:—A

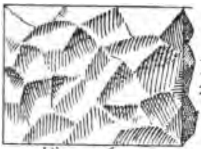
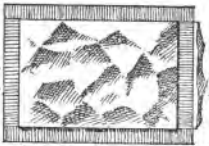


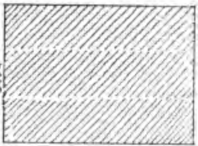
Fig. 236.
Hammer Dressed.

Fig. 237.



Chisel Draughted Margins.

Fig 238



Boasted or Droved.

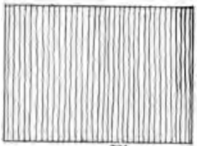
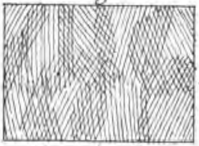


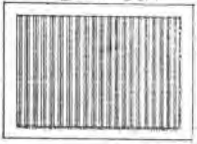
Fig. 239.
Tooled.

Fig. 240.

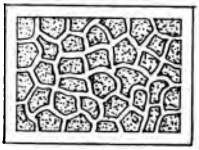


Combed or Dragged.

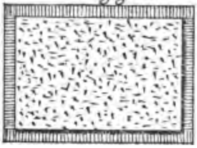
Fig. 241.



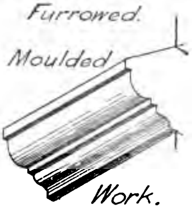
Furrowed.



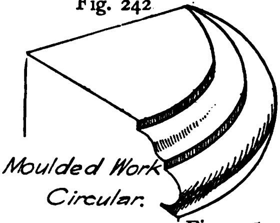
Vermiculated.
Fig. 242



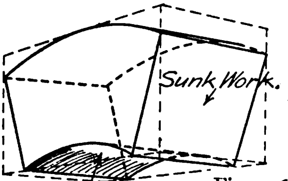
Pointed.
Fig. 243.



Moulded Work.
Fig. 244.



Moulded Work Circular.
Fig. 245.



Sunk Work.
Circular Sunk.
Fig. 246.

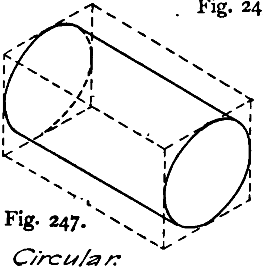
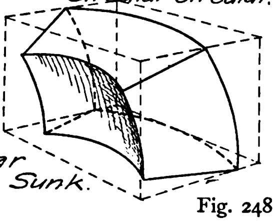


Fig. 247.
Circular.



Circular Circular.
Circular Circular Sunk.
Fig. 248.

margin of about ¾" is marked about the edge of the stone, and in the surface enclosed by the margin a number of irregularly shaped sinkings are made. The latter have a margin of a constant width of about ⅜" between them. The sinkings are made about ¼" in depth. The sunk surface is punched with a pointed tool to give it a rough pock-marked appearance, as shown in figure 242.

Pointed Work.—The bed and side joints of stones are often worked up to an approximately true surface by means of a pointed tool or punch. This labour is often employed to give a bold appearance to quoin and plinth stones, and where so used it usually has a chisel draughted margin about the perimeter.

Moulded Work.—Mouldings of various profiles are worked upon stones for ornamental effect, as shown in figure 244. Mouldings are worked by hand as well as by machine. In the former case, the profile of the moulding is marked on the two ends of the stone to be treated by means of a point drawn about the edge of a zinc mould, cut to the shape of the profile. A draught is then sunk in the two ends to the shape of the required profile. The superfluous stuff is then cut away with the chisel, the surface between the two draughts being tested for accuracy by means of straight-edges. The machines for moulded work somewhat resemble the planing machines for metal work. The stone is fixed to a moving table. The latter has imparted to it a reciprocating rectilinear motion, pressing against a fixed cutter of the shape of required profile, or some member of it. The cutter is moved nearer to the stone after each journey, thus gradually removing the superfluous stuff till the profile is completed. Moulded work is, strictly speaking, the name given to profiles formed with a change of curvature, and, therefore, should not be applied to cylindrical sections, such as columns.

The weathering properties of stones moulded by hand labour are considered by some far superior to those worked by machinery, as in the latter method the moulding irons, being driven continuously, become heated and partially calcine the surfaces of the stones, thus rendering the same peculiarly susceptible to atmospheric deterioration.

Moulded Work, Circular.—This term is given to mouldings, as shown in figure 245, stuck upon circular or curved surfaces in plan or elevation.

Sunk Work.—This term is applied to the labour of making any surface below that originally formed, such as chamfers, wide grooves, the sloping surfaces of sills, etc., as shown in figure 246. If the surface is rough, it is known as half-sunk; if smooth, sunk; and any other labour applied must be added to the same, such as sunk, rubbed, etc.

Circular Work.—Labour put upon the surface of any convex prismatic body, such as the parallel shaft of a column or large moulding, is termed circular work, as shown in figure 247.

Circular Sunk Work.—Labour put upon the surface of any concave prismatic body, such as a large hollow moulding or the soffit of an arch, is termed circular sunk work, as shown in figure 246.

Circular Circular Work.—The labour placed upon columns with entases, spherical or domical work, as shown in figure 248.

Circular Circular Sunk.—The labour worked upon the interior concave surfaces of domes, etc., as shown in figure 248.

Internal Mitres.—The name given to the intersection of two mouldings making an angle less than 180°.

External Mitres.—The name given to the intersection of two mouldings making an angle greater than 180°.

Returned Mitred and Stopped.—The name given to a moulding returned in itself, and stopping the same against an intersecting surface.

Long and Short Work.—This work is usually used for quoins and dressings in rubble walls, and is especially noticeable in old Saxon work. It consists in placing alternately a flat slab, which serves as a bonder, and a long stone approximately small and square in section.

This arrangement in modern work is sometimes known as block and start work.

Stone Walling.—Is divided under the following headings:

1. Rubble. 2. Block in Course. 3. Ashlar.

Rubble walls are those built of thinly-bedded stone, generally under 9 inches in depth, of irregular shapes as in random rubble, or squared as in coursed rubble.

Block in course is composed of squared stones usually larger than coursed rubble, and under 12 inches in depth.

Ashlar is the name given to stones, from 12 to 18 inches deep, dressed with a scabbling hammer, or sawn to blocks of given dimensions and carefully worked to obtain fine joints.

The length of a soft stone for resisting pressure should not exceed three times its depth; the breadth from one-and-a-half to twice its depth; the length in harder stones 4 to 5 times its depth, and breadth 3 times its depth.

Random Rubble.—The name given to walling built of stones that are not squared.

Random Rubble set Dry.—In the stone districts boundary walls are built of rubble set without mortar in courses about

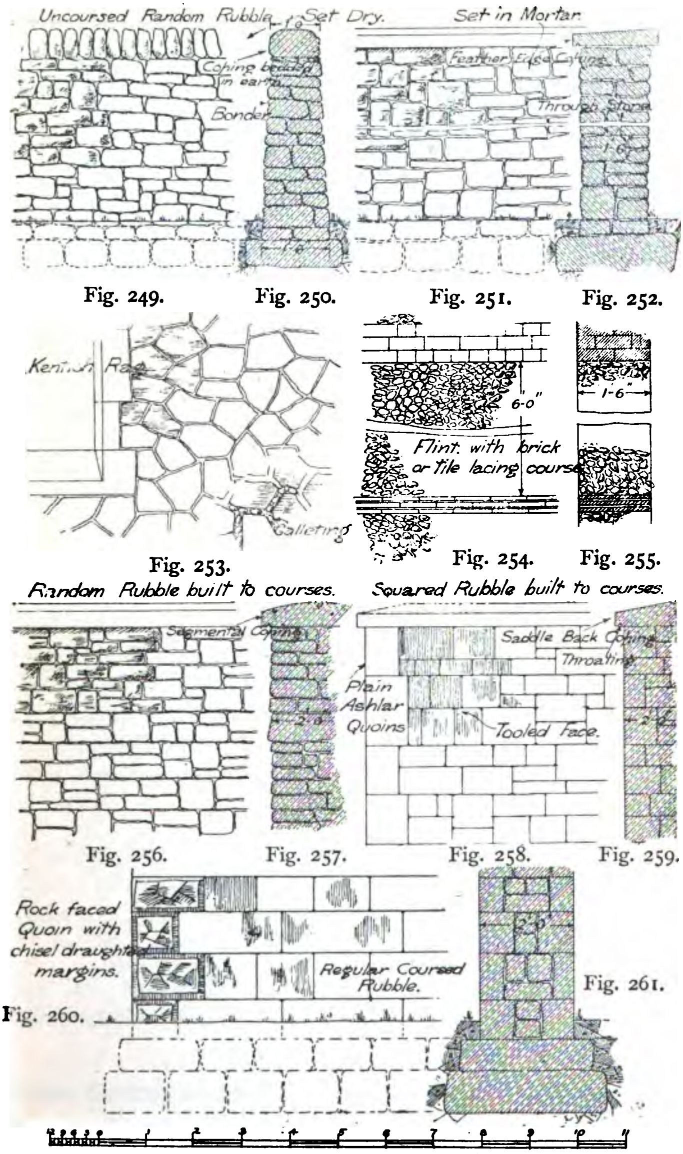


Fig. 249. Fig. 250. Fig. 251. Fig. 252.

Fig. 253. Fig. 254. Fig. 255.

Fig. 256. Fig. 257. Fig. 258. Fig. 259.

Fig. 260. Fig. 261.

Figs. 249–261. Varieties of Walling.

12 inches high, provided with a waterproof top, as shown in figures 249 and 250, to keep water from getting into the body of the work, and bursting it in frosty weather.

Uncoursed Random Rubble set in Mortar.—The stones are used as they come from the quarry, care being taken to obtain them as uniform as possible, the bond being obtained by fitting in the inequalities of the stone, and by using one bond stone every super yard on face; any openings between stones to be pinned in with spalls, as shown in figures 251 and 252. If good mortar is used, walls built of random rubble should be made one-third thicker than the thickness necessary for brick walls.

Kentish rag stone is an unstratified stone found in Kent, and is used largely for walls. Figure 253 shows an elevation of this type of random rubble walls.

Random Rubble built in Courses.—This consists of stones forming horizontal beds at intervals of 12 to 18 inches, every stone being bedded in mortar. The object being to ensure that there shall be no continuous vertical joints, as illustrated in figures 256 and 257. To save expense in bedding each stone in mortar, masons bed only the stones on faces of wall, and at these levels pour a pail of thin mortar, called grout, to fill up any cross joints between stones, taking care not to let any run over the face of wall.

Uncoursed Squared Rubble.—Stones roughly squared and hammer or axe faced, the vertical depth of the stones usually being less than 9″, as shown in figures 262 and 263, are sometimes called irregular coursed or snecked rubble.

Squared Rubble built in Courses.—Figures 258 and 259 show squared rubble brought up to level beds with hammer-dressed quoins and chisel-draughted margins.

Regular Coursed Rubble.—In this kind of work all stones in one course are squared to the same height, usually varying from 4″ to 9″, as illustrated in figs. 260 and 261, and are generally obtained from thin but regular beds of stone.

Fig. 262.

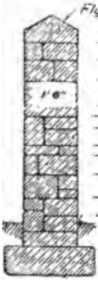
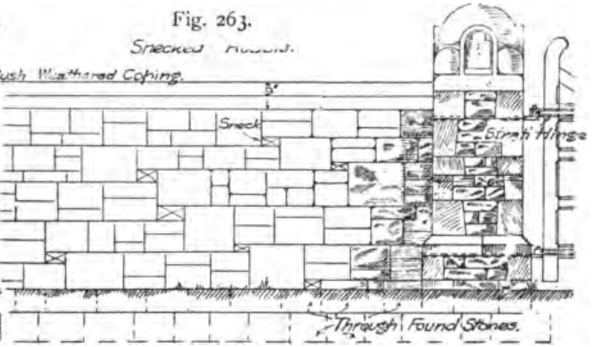
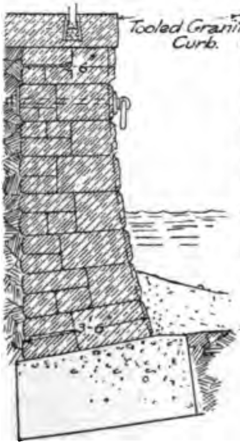


Fig. 263.





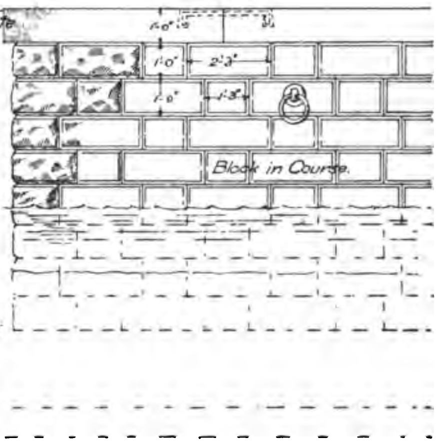
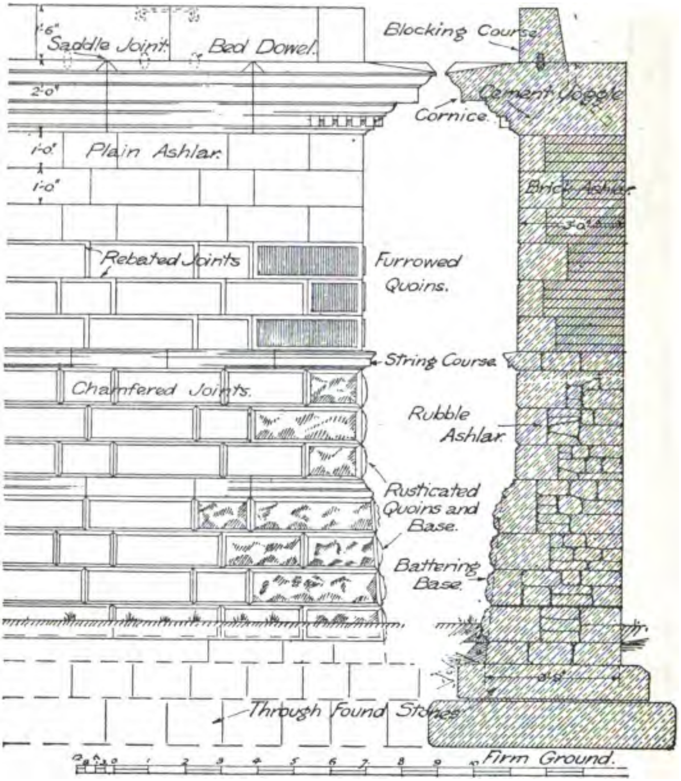


Fig. 264.

Fig. 265.

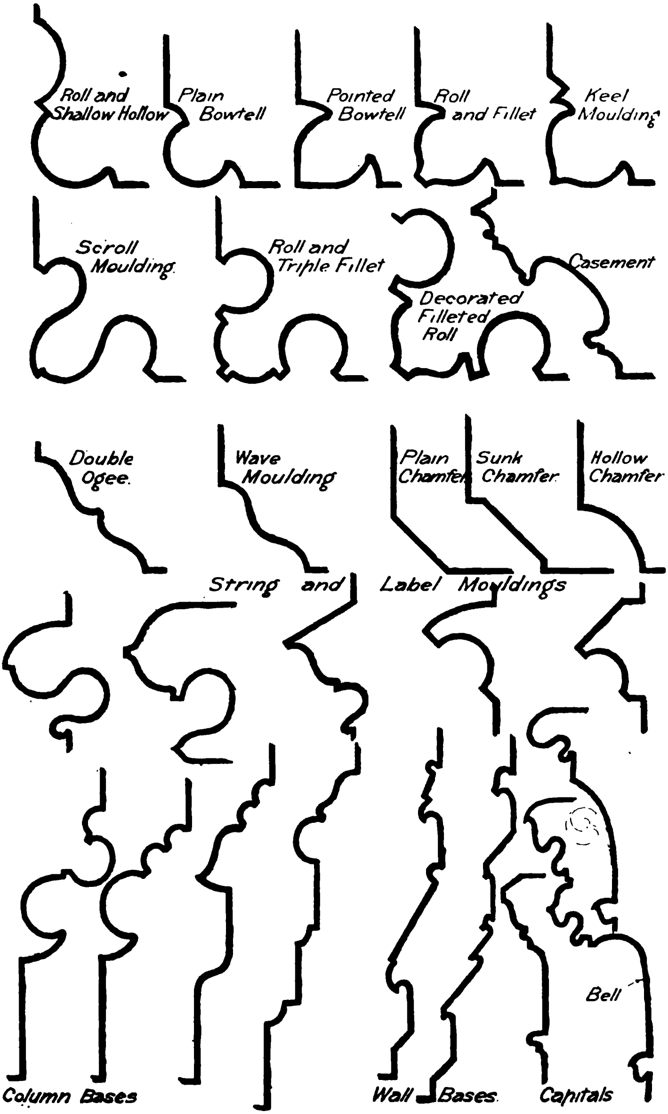
Block in Course is the name applied to stone walling, chiefly used by engineers in embankment walls, harbour walls, etc., where good work is required. The stones are all squared and brought to good fair joints, the faces usually being hammer-dressed, as shown in figures 264 and 265. Block in course closely resembles coursed rubble, or ashlar, according to the quality of the work put upon it.

Fig. 266. Fig. 267.



Ashlar.—Ashlar is the name applied to stones that are carefully worked, and are usually over 12″ in depth, and have joints not more than ⅛ inch thick.

As the expense would be too costly to have walls built



Figs. 268–295. Types of Gothic Mouldings.

entirely of ashlar, they are constructed to have ashlar facing and rubble backing, or ashlar facing and brick backing, both shown in figures 266 and 267; but, as the backing would have a greater number of joints than the ashlar, the backing should be built in cement mortar, and brought to a level at every bed joint of the ashlar, to ensure equality of settlement.

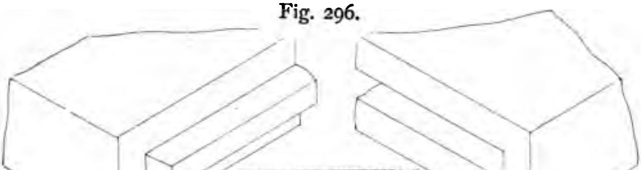
The ashlar facing may be plain, rebated, or chamfered, as illustrated in figure 266, and looks best when laid similar to Flemish bond in brickwork.

Mouldings.—Figures 268 to 295 give a selection of the mouldings commonly used in the Gothic periods, combinations in archivolts, also for strings, wall bases, bases and capitals of columns. Types of the mouldings employed in the classic periods are shown in the Chapter on Joinery.

Joggles.—A joggle is a form of joint in which a portion of the side joint of one stone is cut to form a projection, and a corresponding sinking is made in the side of the adjacent stone for the reception of the projection, as shown in figures 296 and 297. It is chiefly used in landings to prevent any movement between the stones joined and so retain a level surface between same, and also to assist in distributing any weight over every stone in the landing.

Tabling Joints.—This is a form of joint that has been used to prevent lateral motion in the stones of a wall subjected to lateral pressure, such as in a sea-wall. It consists of a joggle joint in the bed joints, the projection in this case being almost 1½" in depth and a third of the breadth of the stone in width, as shown in figure 298. This kind of joint is rarely used now owing to the great expense in forming it, it being superseded for sea-walls by huge blocks of concrete cast on or near the spot, of a weight sufficient to resist any pressure likely to be brought to bear on them, and usually under other conditions by long slate joggles placed in a space to receive same

Fig. 296.



Joggle.

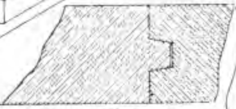


Fig. 297.

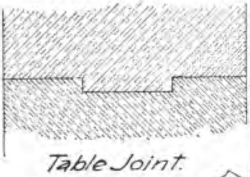


Table Joint.

Fig. 298.

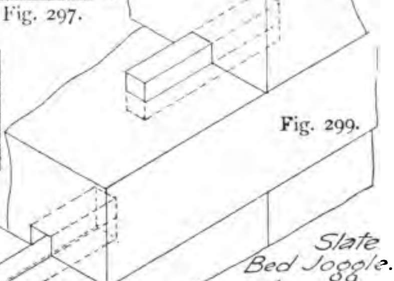


Fig. 299.

Slate Bed Joggle.

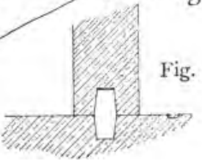


Fig. 303.

Bed Dowel.

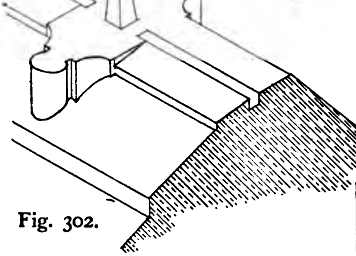


Fig. 302.

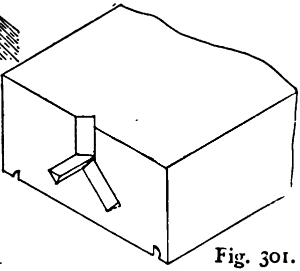
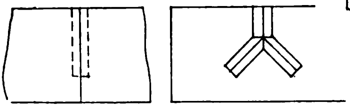


Fig. 301.



Portland Cement Joggle.

Fig. 300.

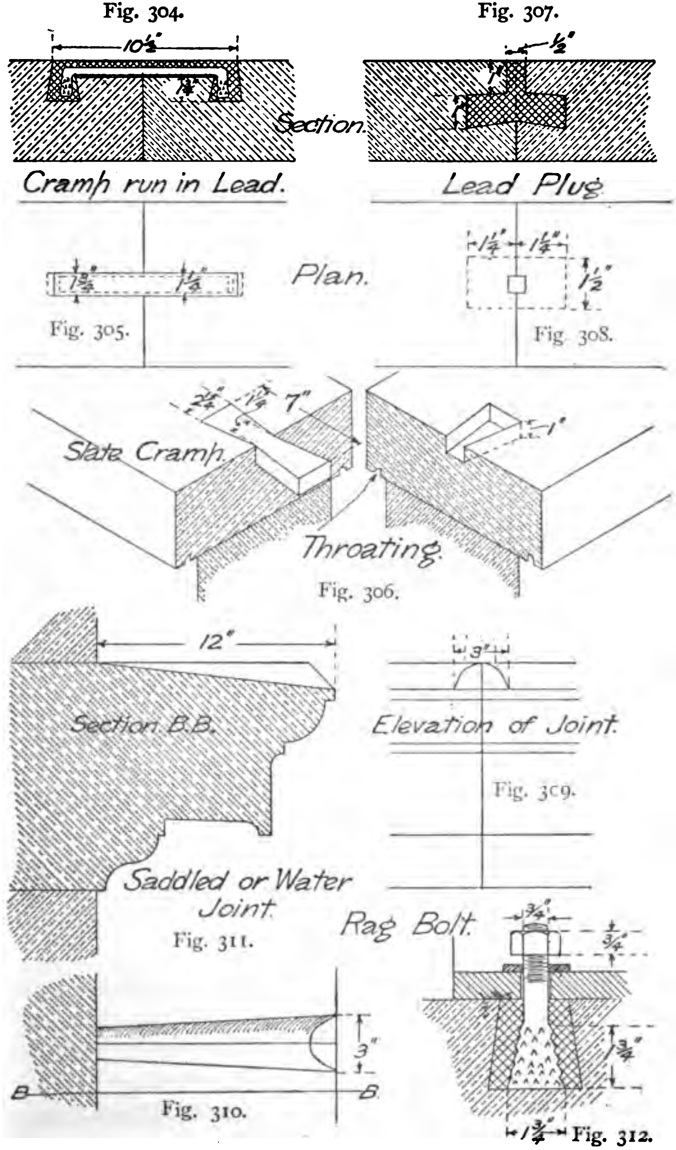
in the bed joint at the junction of side joints of two stones and the top bed joint of another, as shown in figure 299. These were used in the piers of the new Tower Bridge.

Cement Joggles.—These are generally used in the side joints of the top courses of masonry to prevent lateral movement in the same, and consists of a V-shaped sinking in the side joint of each adjacent stone in the same course, as shown in figures 300 and 301.

Dowels.—Dowelling is another method of obtaining the same result as joggling or tabling. The dowels consist usually of pieces of hard stone or slate about one inch square in section and varying from about two inches to five inches in length, slightly tapering from the centre towards the two ends, as shown in figures 302 and 303, being sunk and set in cement in corresponding mortices in the adjacent stones. They are used in both the side and bed joints. They are generally employed in the top courses of masonry where the weight on or of the individual stones is not great. The united mass thus formed from the collected stones renders any movement impossible under normal conditions.

Pebbles.—Small pebbles used to be commonly employed to connect stones before the introduction of slate joggles owing to the ease with which the latter may be fitted. The pebbles are still sometimes used for small work.

Cramps.—Metal cramps are used similarly to dowels to bind work together, but are more particularly adapted for positions in which there is a tendency for the stones to come apart, such as in copings covering a gable, or in face stones of no great depth, or cornices and projecting string courses to tie the same to the body of the wall. The cramps are made from thin pieces of metal of varying lengths and sectional area according to the work, turned down about 1½" at each end. The ends are made rough and inserted into mortices, and the



Figs. 304–312. Fastenings and Saddled Joint.

body of the cramp into dovetailed shaped mortices, and a chase made to receive same in the stones to be connected, as shown in figures 304 and 305. The cramps are usually prepared from either wrought iron, copper, or bronze. If wrought iron is used, it is usually subjected to some preservative process, such as tarring and sanding or galvanising, to prevent oxidation. Iron is useful on account of its great tensile strength. Copper is valued for its non-corrosive properties under ordinary conditions, and its tensile strength, which is not much less than wrought iron; it is, however, comparatively soft. Bronze partakes of properties similar to those of copper, with the exception that it is much harder, which, under some conditions, is a desideratum.

The best bedding materials are Portland cement, sulphur and sand, and asphalte. Care should be taken to completely envelope the cramp in the bedding material. Lead is not now considered good for external work owing to its liability to form a galvanic couple with the cramp in the presence of moisture, in addition to the oxidation. Occasionally stones are connected by slate cramps set in cement, as shown in figure 306.

Lead Plug.—Stones may be connected together by means of lead in the following manner, shown in figures 307 and 308:—Dovetailed shaped mortices of the form shown are made to correspond in the side joints of two adjacent stones, into which, when placed in position, molten lead is poured, and when cool is caulked, thus completely filling the mortices and connecting the pieces.

Rag Bolt.—The ends of the bolts are often fixed by having the end that is let into the stone jagged, and run with lead, or sulphur and sand, the mortice being dovetail shaped, as in figure 312, to secure it from any upward pressure.

Where there is any probability of a great upward stress a hole is drilled right through the stone and a bolt supplied with a washer passed through in the ordinary manner.

Saddled or Water Joint.—To protect the joints of cornices and other exposed horizontal surfaces of masonry the sinking is sometimes stopped before the joint and weathered off, as shown in figures 309 to 311. Any water passing down the weathered surface is guided away from the joint. The expense of this joint often prohibits its use.

Rebated Joints.—These joints are used for stone roofs and copings to obtain weather-tight joints. There are two kinds: (1) when both stones are rebated; (2) when the upper stone only is rebated. In the first case the stones are of the same thickness throughout, their upper surface being level when the joint is made. In the second case the stones are thicker at the bottom edges than at the top, the bottom edge having a rebate taken out equal to the thickness of the upper edge of the stone below it, over which it fits. The part that laps over should not be less than ¾″ thick. The under surfaces or beds of the stones should be level, as shown in figures 233 and 234.

Stone Arches.—The general remarks, definitions, terms, etc., made in the previous chapter on brick arches, apply also to the stone arches, differing only slightly in construction. The openings in stone of small span are generally bridged by stone lintels in one piece, or lintels built on an arched construction if a number of stones are used. If lintels of one piece are employed in walls other than ashlar, a rough arch is generally built above to relieve the lintel of the weight of the superincumbent wall, as shown in figures 313 to 315. A second method of relieving the lintel commonly adopted in snecked rubble work is to construct a flat arch of three stones above the lintel, as shown in figures 316 to 318; the centre stone or key is termed the save. In bedding the save stones

Fig. 313.

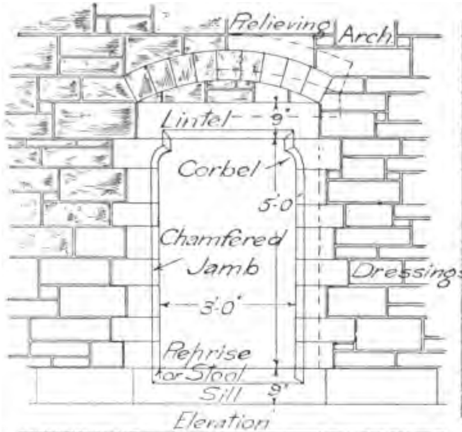


Fig. 315.

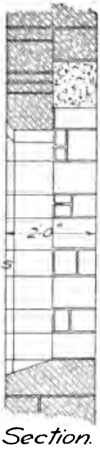


Fig. 314.

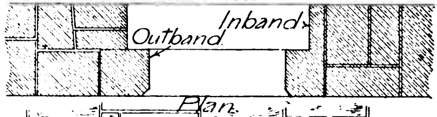
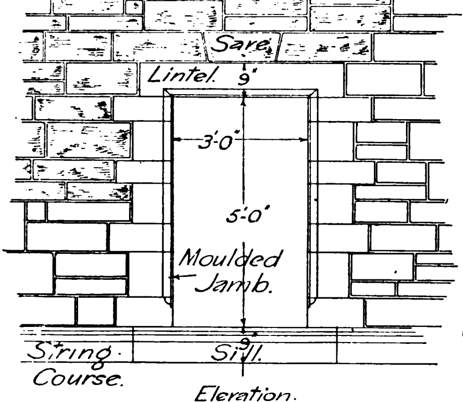


Fig. 316.



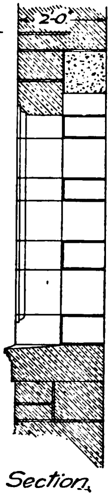
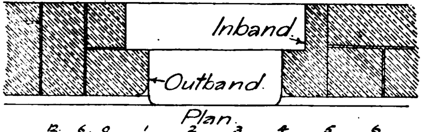
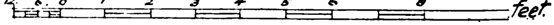


Fig. 317.

Fig. 318.





Figs. 313–318.

Fig. 319.

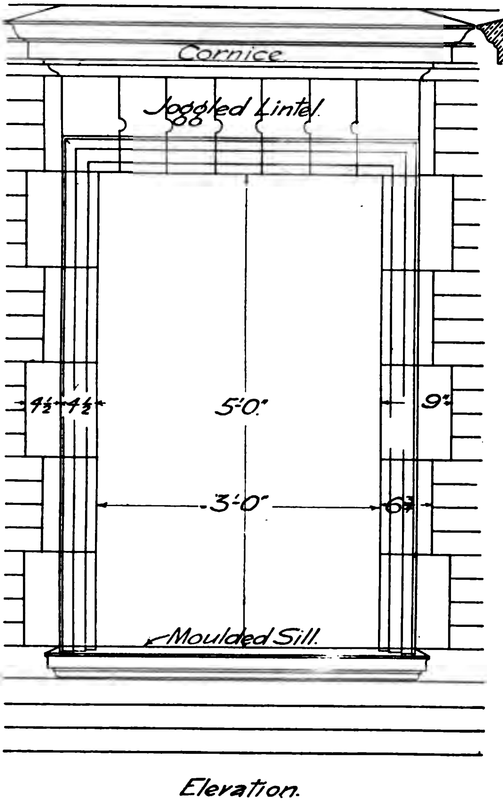
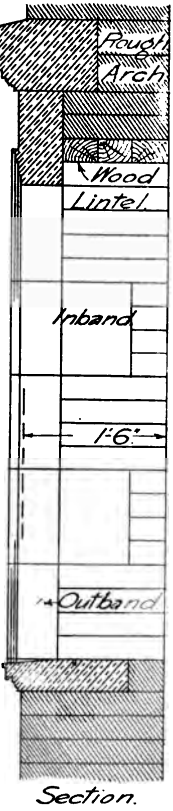


Fig. 320.



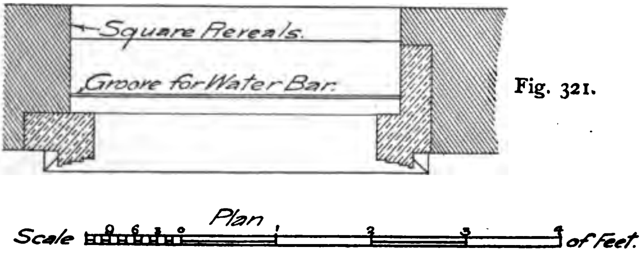


Fig. 321.

Figs. 319–321.

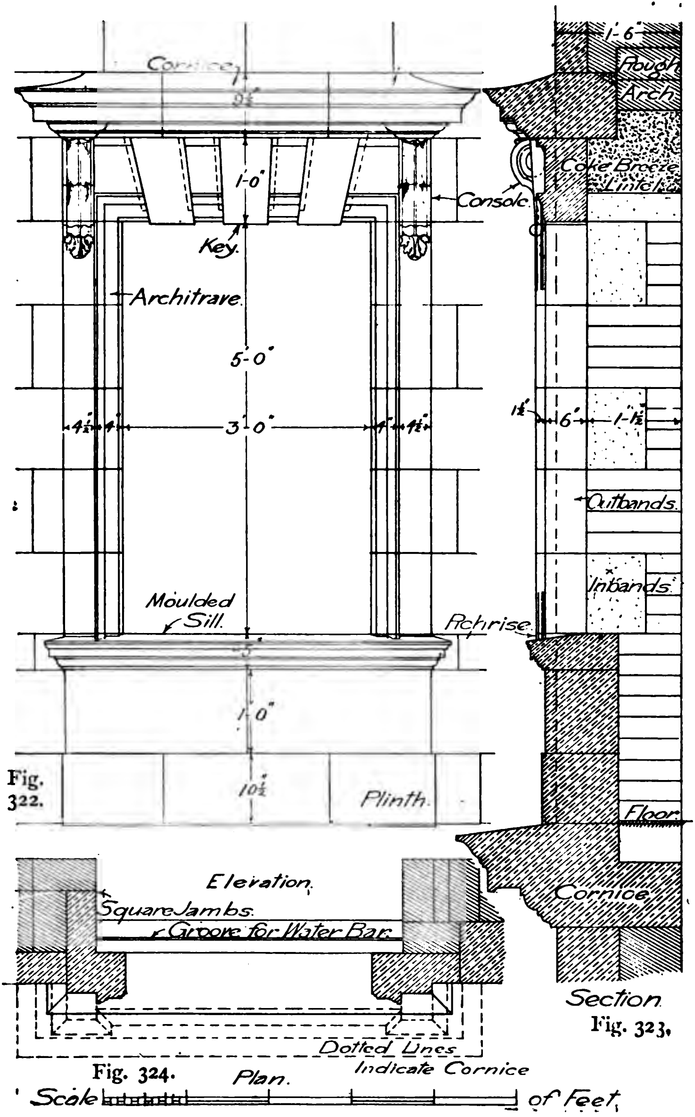


Fig. 322.

Fig. 323.

Fig. 324.

Figs. 322–324.

no mortar is placed on the lintel, but the stones are supported in their position by means of small wood wedges. After a sufficient mass of the wall has been built to tail down the side saves the wedges are removed. In finishing the wall, the joint between the saves and the lintel is pointed only, thus no weight from the wall above is brought to bear on the lintel.

A large number of stone openings are formed with flat heads, and where stones of sufficient dimension cannot conveniently be obtained in one piece, some form of flat arch is adopted.

Figures 319 to 321 show a joggled lintel in this example; the joints are vertical, the intermediate stones being kept in their place by a semicircular joggle from front to back of every pair of bed-joints in the centre of each block. This form is also largely used for terra-cotta work.

Figures 322 to 324 show a flat arch, with secret joggles. These latter are worked out of the solid stone, the key having two joggles; the springer is recessed only, and is made sufficiently long to tail well into the wall, the remaining voussoirs being joggled on one bed-joint and recessed on the other; the cornice over window in this example is supported by a console or bracket.

Figures 325 to 327 show the construction as a flat arch, the bed-joints stepped to prevent any voussoir sliding on its bed-joint. This method is largely used for terra cotta work. This example illustrates an architrave about window, supported at sides by a half column with cushion frieze and segmental pediment above. The internal jambs are splayed, and illustrate the use of scontions. A coke breeze lintel cast *in situ* is shown over the internal opening, the upper surface being segmental, upon this a rough stone arch is constructed to relieve lintel.

Figures 328 to 330 show a flat arch with projecting voussoirs. About the opening is an architrave with a frieze and pediment over. The first voussoir projects sufficiently to

Fig. 325.

Fig. 326.

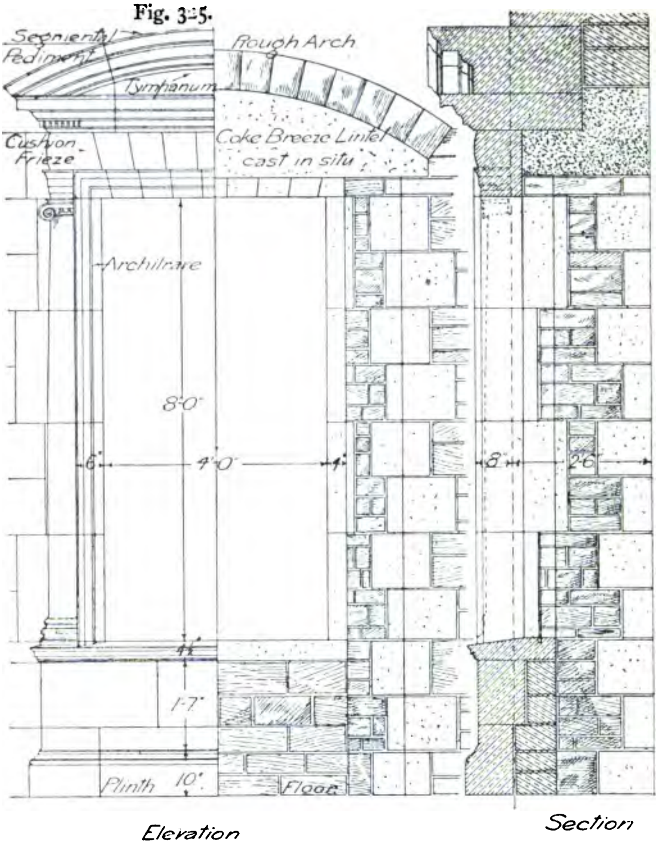
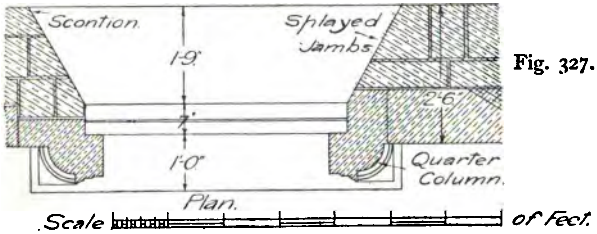


Fig. 327.



Figs. 325–327.

Fig. 328.

Fig. 329.

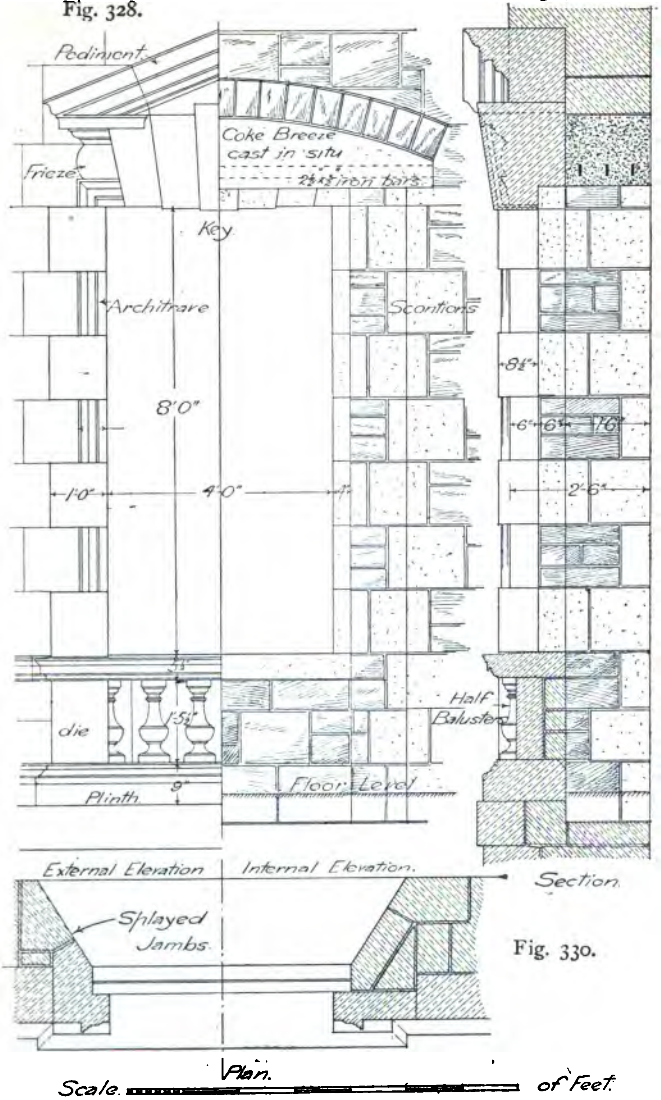
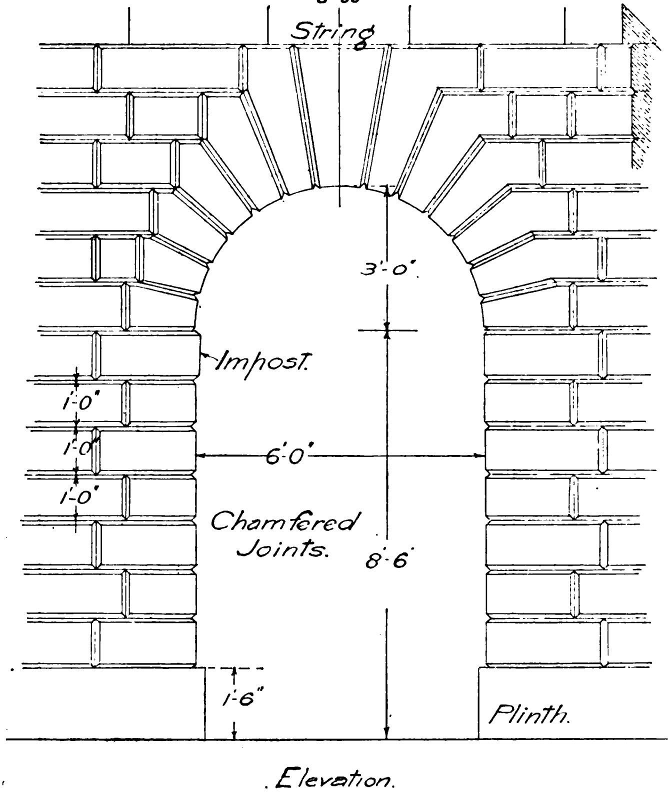


Fig. 330.

Figs. 328–330.

Fig. 331.



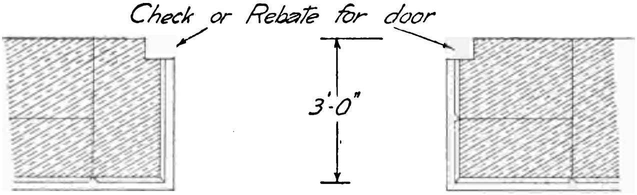


Fig. 332.

Figs. 331, 332.

interrupt the frieze and bed moulding, the second voussoir projects about an inch beyond the first and extends upwards to the top of the corona, the latter being returned in itself against the first voussoir to prevent an unsightly intersection. The key projects about an inch further and extends into the tympanum of the pediment. The architrave is interrupted by rectangular blocks, the latter projecting about half an inch.

The sill forms the cornice of a pedestal as shown, being supported beneath the opening by stone balusters. The internal opening has splayed jambs with a coke breeze concrete lintel strengthened by iron bars, and being segmental on upper surface. This form of lintel is extensively used where the pressure from above is considerable. The lintel is relieved by a rough discharging arch.

Figures 331 and 332 illustrate a semicircular opening in an ashlar wall, the blocks of which have chamfered joints. In these arches it is necessary to extend the bed joints of the voussoirs till they intersect the courses of the work; this results in the voussoirs gradually getting longer as they approach the key. A better method of arranging voussoirs is shown on right hand of figure 331. In this the bed joints of the voussoirs are extended to meet the horizontal courses, and are then returned a convenient distance along the horizontal course; this prevents the vertical joints of the voussoirs coming too close together near the springing.

Fig. 334.

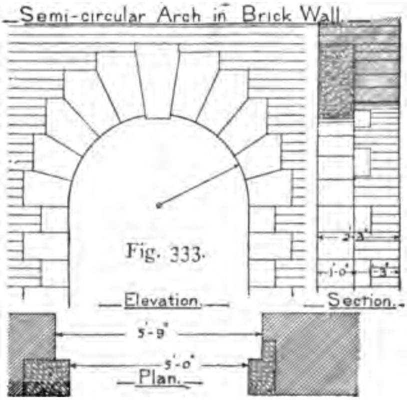


Fig. 335.

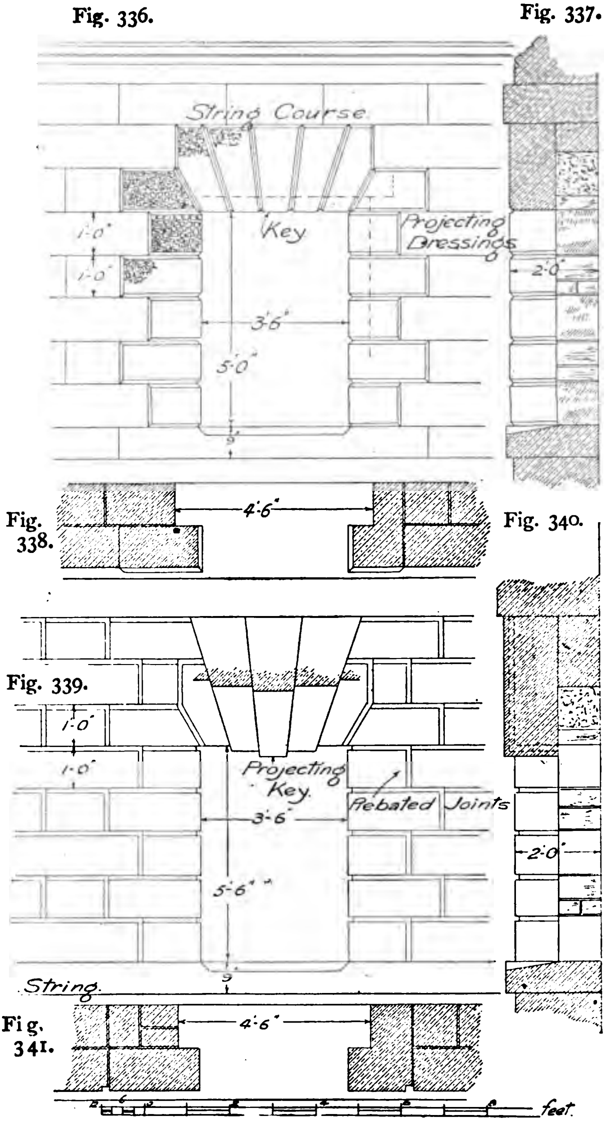


Fig. 336.
Fig. 337.
String Course
Key
Projecting Dressings
1-0"
1-0"
3-6"
5-0"
9
2-0"
Fig. 338.
4-6"
Fig. 340.
Fig. 339.
1-0"
1-0"
Projecting Key
Rebated Joints
3-6"
5-6"
9
String
2-0"
Fig. 341.
4-6"
feet

Figs. 336–341.

Figures 333 to 335 show a semi-circular stone arch built in a brick wall.

In setting out the voussoirs are divided up equally on the soffit, and the bed joints are struck radially from the centre.

The greatest width of the voussoirs is made to equal some multiple of the thickness of a brick, 3, 4, or 5 courses as required. The first bed joint is produced till it cuts the desired bed joint of the bricks. The boundary of the voussoir from this point deflected horizontally for about 4″ to 6″ and vertically upwards for another 4 or 5 courses, the second radial joint is then struck and produced to the same level; these two points are joined by a horizontal line and the second voussoir is then completed. This operation is repeated till the arch is finished. It should be observed that the depth of the arch increases towards the crown, as set out by this method.

In all wrought stonework the voussoirs are accurately set out with templets and cut.

Figures 336 to 338 show a rectangular opening, the dressings and voussoirs of arch spanning same project beyond the wall face about 1½ inches, they have chamfered joints and are vermiculated on surface to give importance to the opening; this form of opening is commonly adopted in the basement stories of classical buildings.

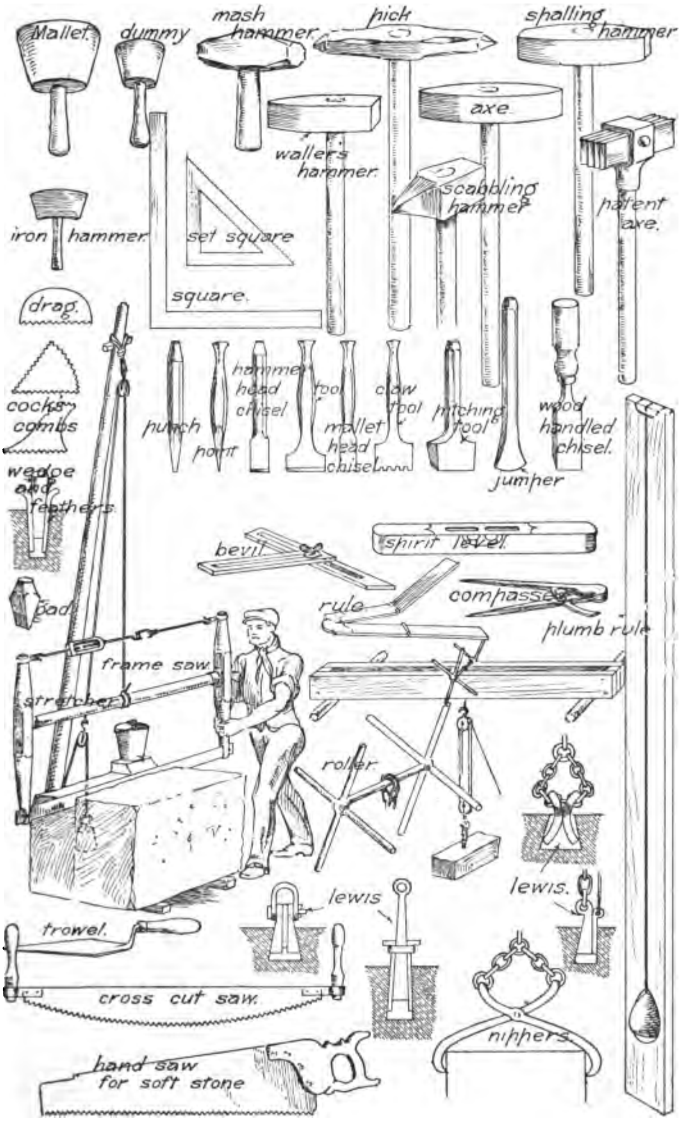
Figures 339 to 341 show a similar opening, the voussoirs projecting as they approach the key, and the joints of the masonry being rebated. This is also used for basement stories of classical buildings.

Tools.—Figures 342 to 382 show the tools commonly used by masons.

Masons' Tools : Hammers and Mallets.—1. The mallet is formed of a truncated cone of hard wood with handle, and is used for striking the mallet-headed chisels. 2. The dummy is similar in form, but with a smaller head, and generally used in carved work. 3. Iron hammer: This has a head similar to a carpenter's mallet, but made of iron; this is used for carved work. 4. The mash hammer: this has a heavy head and short handle, and is used upon the hammer-headed chisels. 5. The waller's hammer, used for roughly squaring stones in rubble work. 6. The pick: this has a long head, pointed at both ends, and weighs about 16 lb.; used for roughly dressing granite and also for splitting other stones in the quarry. 7. The axe has a head shaped like a double wedge, and of about 12 lb. in weight, used for forming a labour, similar to tooled work upon granite. 8. Patent axe: this is also used for fine axed granite work, and consists of a number of plates bolted together in a head formed specially. 9. Spalling hammer, used for roughly dressing stones in the quarry. 10. Scabbling hammer, has one end pick-pointed, and is used for roughly dressing hard stones in the quarry.

Setting out and setting tools. 1. The square, formed of iron, each arm being about 18 inches long. 2. The set square formed of iron, set to 45° or other angles as required. 3. The bevil, formed of two blades of iron slotted and fastened with a thumbscrew. 4. The spirit level, which should be at least 18 inches long. 5. Compass for dividing. 6. The rule. 7. The plumb rule and bob for testing verticality. 8. The trowel for spreading mortar.

Cutting Tools.—Chisels are divided into two classes—those for use with the hammer, and those for use with the mallet. The hammer-headed chisels have the section of their striking end made smaller, to lessen the amount of burr. The mallet-headed chisels have their striking ends made broader to avoid injuring the mallet. 1. The punch has a cutting edge about a ¼" long, it is used with the hammer for removing superfluous stone in roughly dressing. 2. The point has an edge similar to that of the punch, but is used with the mallet for hard stones. Hammer and mallet-headed chisels are made with lengths of edges from ¼" to 1¼" wide; mallet-headed chisels from 1½" edge upwards are termed boasters for tooling surfaces. The



Figs. 342-382. Mason's Tools.

claw tool has an edge with a number of teeth from $\frac{1}{8}''$ to $\frac{3}{8}''$ in width, and is used for dressing surfaces of hard stones after the point or punch has been used. The pitching tool has a long edge with a thick point, and is used with the hammer for reducing stones. Jumpers are used for boring holes in quarrying granite, or for blasting operations; they are of varying lengths, and have their edges in length greater than the diameter of the tool, so that they may be turned round in the hole being bored. The wood-handled chisel, similar to a carpenter's firmer chisel, and used upon Bath and other soft stones. The drag is a piece of steel plate with an edge cut similar to a saw tooth and is used for bringing or dragging the surfaces of soft stones to a uniform level. Cockscombs are specially shaped drags for moulded work in soft stones. The wedge and feathers, used generally for splitting granite, consists of a conical wedge and two thin curved plates; these are placed in a series of holes made by a jumper along a required line of section for severing the stone apart. Gads are small iron wedges used for splitting softer stones; these are inserted in chases made by the pick.

Saws Worked by Hand.—1. The hand saw, 28″ in length, and used for cutting soft stones, is similar to a carpenter's half rip saw. 2. The double-handed saw, from 5 to 6 feet in length, to be worked by two men. 3. The frame saw, used for cutting large blocks of stone, consists of a frame as shown in figure, the weight of which is supported by being slung on to a system of pulleys arranged to give the saw the required amount of vertical play. The blade of this saw consists of a piece of steel about $\frac{1}{10}''$ in thickness and 4″ in width, and is fixed to the frame by means of two steel pins. The cutting action is assisted by coarse sand and water, which is allowed to dribble into the cut from a tinware vessel placed conveniently by the side of the work. The saw should be about 2 feet 6 inches longer than the stone to be cut, for this purpose blades and stretchers of varying lengths are kept; and the coupling irons at the top may be increased in length by the addition of loose links.

Hoisting Apparatus. — 1. The nippers consist of two curved and pointed arms rotating on a pivot, and fitting into notches cut on the sides of the stone; the tendency is to bite more tightly as it is lifted. These are convenient for manipulating stones too large to be easily handled. It is necessary where stones are too large to be easily lifted that they should be placed exactly in their position by the lifting apparatus, to avoid disturbing the green work underneath. For this purpose lewises, which are arrangements of dovetailed shaped blocks, are let into a special hole cut into the top bed. Four varieties are shown in the plate. 2. The scaffold jib, as shown in figure, is employed where a derrick or other crane is not used, and where the stones are first raised on the scaffold, and from there manipulated to their bed; it consists of two timbers, about 9″ or 11″ by 3″, according to the weight to be lifted, bolted together at their ends, and leaving a space of about 4″ between the timbers; it is supported by the ledgers of the inside and outside scaffolds at a convenient height above the work, it is supplied with an iron roller of about 1½″ diameter with four arms at each end, the chain supporting the pulleys is passed over the roller, and the stone when raised can be moved in a transverse direction by turning the levers of the roller.

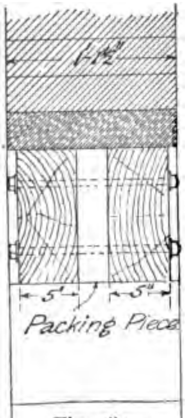
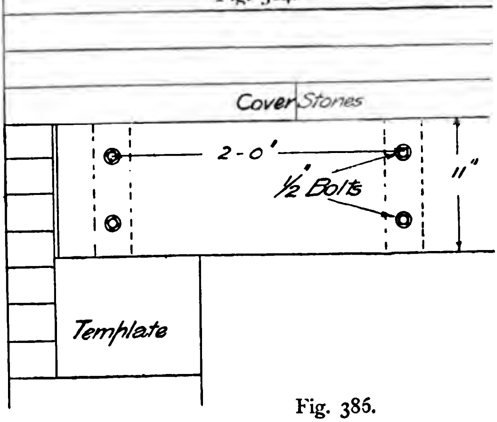


Fig. 383.

Fig. 384.



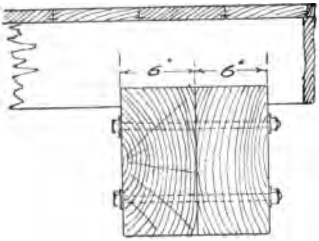
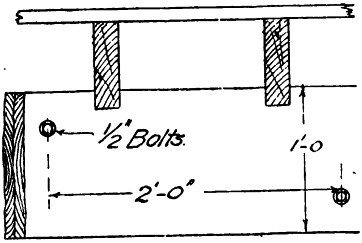


Fig. 385.

Fig. 386.



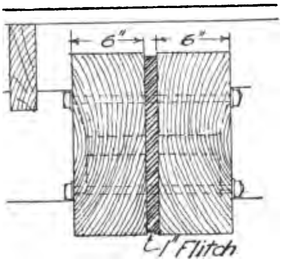


Fig. 387.

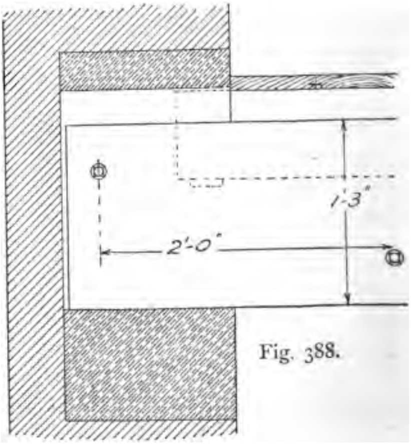


Fig. 388.

Figs. 383-388. Examples of Girders.

CHAPTER IV.

GIRDERS.

Definition.—Members of buildings which are in one piece, or built up to form one member, and used to span openings and support loads, and which are subjected to a transverse stress, are called girders, and may be either straight or curved and of various sections.

Classification.—They may be of (*a*) wood, (*b*) wood, halved, reversed and bolted, (*c*) flitched beams, (*d*) built-up beams, (*e*) trussed beams, and when entirely of metal may be of cast iron, wrought iron or steel. The sections of the latter two, may be rolled joists or rolled sections built up as plate, box, lattice, Warren girders, etc.

Girders fixed at one end and free at the other are called semi-beams or cantilevers; when supported or fixed at both ends, they are known as beams.

A load carried by a beam supported only at its ends would cause the upper fibres of the beam to be in compression, and the lower to be in tension. The neutral plane is an imaginary plane containing the fibres of that part of the beam which is neither in tension nor compression.

Bressummer, or *breastsummer.*—A girder with a wide supporting surface, acting as a lintel, as shown in figures 383 and 384; as in the case of a beam supporting a brick or stone wall over a shop front, bay window, etc.

Wood Girders.—These are usually employed in uniform rectangular sections, and to ensure against lateral bending, the minimum breadth should be ·6 of the depth.

Flitch Girders.—These are formed by sawing, reversing, and bolting timbers, as in figures 383 to 386. Where the dimensions are such that the whole section of the log is necessary to obtain the required scantling, it is usual to cut the timber depthways through the heart, to season the wood, for the purposes of inspection. The butt end of one piece is placed against the top end of the other, to ensure a uniformity of strength throughout, and to allow the timber to shrink without developing large shakes. The two flitches are placed together with their heart sides outwards, this operation is known as halved and reversed, after which it is bolted.

Figures 383 and 384 show a flitch girder, the flitches being blocked apart to carry a wall, the thickness of which is greater than the sum of the widths of the flitches.

Figures 385 and 386 show an ordinary flitch girder, halved, reversed and bolted.

Iron Flitch Girder.—To further strengthen a wood girder, a wrought-iron plate or flitch is inserted between the cut timber and bolted, as shown in figures 387 and 388. To prevent the girder riding on the iron flitch when the timber shrinks, the iron is kept $\frac{1}{4}''$ from the top and bottom surfaces, or chases are made in the templates and the cover stones if employed as a bressummer.

Laminated Beams.—Wood beams required of a length not obtainable in the market, or with a sharp curvature as for the ribs of a centre or dome, are sometimes built up in layers, as shown in the chapter on Joints in Carpentry.

There are two methods of lamination, vertical and horizontal. Where timbers are required to be of a curved form, such as curved beams, curved roof timbers or ribs of centres, the vertical laminated method is much used, as works of curvature can be readily made by this method. The horizontal method of lamination is applicable for curved beams of great span on

Fig. 389.

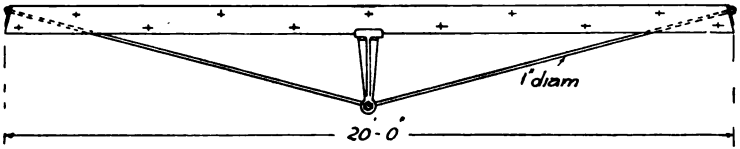


Fig. 390.

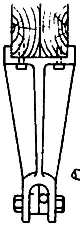


Fig. 391.

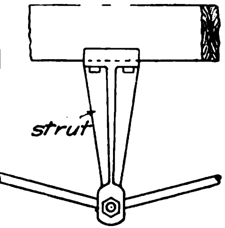
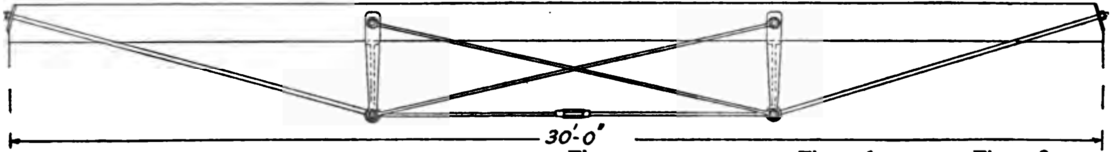


Fig. 392.



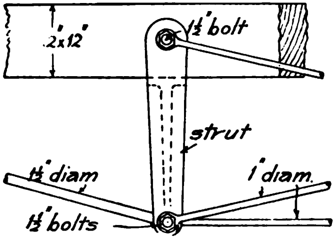


Fig. 393.

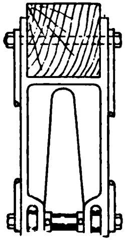


Fig. 394.

Fig. 395.

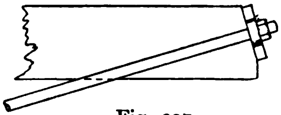


Fig. 396.

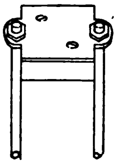
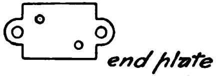


Fig. 397.



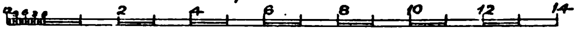


Fig. 398.

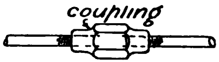
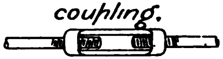


Fig. 399.



Figs. 389–399. Types and Details of Trussed Wood Beams.

account of the comparative fewness of butt joints, but for general purposes is rejected on account of the relatively great expense in production.

Trussed Wood Beam.—To avoid clumsy and heavy sections in timber, where great strength is required, iron, which offers greater tensile resistance than timber, is often substituted for the lower and tensional portion of the beam.

Figures 389 to 399 show the types and details which are greatly employed for the beams of travellers, and for purlins of roofs.

Figures 398 and 399 show types of couplings used for adjusting the lengths of the bars.

Wood Pillars.—Timber of rectangular section is largely used for story posts and struts. The method of determining the resistance of pillars, stanchions, struts, etc., is very complex, and no formula has yet been determined to give the exact value of the resistance. The most satisfactory formula, as explained in the advanced course, is that given by Rankine and Gordon, as follows:—

$$p = \frac{f}{1 + a\frac{l^2}{h^2}}$$

p = pressure per unit of sectional area.
f = intensity of pressure to crush a short column of one square inch sectional area.
a = constant deduced from experiments on the actual breaking weight of long columns.
l = length of bar in same unit as h.
h = least transverse dimension of a triangle or rectangle circumscribing the section of the bar.

The value of a for dry timber, ends flat or fixed, which latter is the usual condition of timber pillars or struts, is $\frac{1}{250}$. If the ends are rounded, the value of a is multiplied by 4. The value of f for dry northern pine is taken as $2\frac{1}{4}$ tons or 5040 lbs.

The following table has been calculated upon the above data and will be found useful in practice:—

$\frac{l}{h}$ or ratio of length to least dimension.	Value of p, or ultimate pressure in lbs. per square inch.	$\frac{l}{h}$ or ratio of length to least dimension.	Value of p, or ultimate pressure in lbs. per square inch.
5	4,582	29	1,155
6	4,406	30	1,096
7	4,214	31	1,040
8	4,013	32	989
9	3,807	33	941
10	3,600	34	896
11	3,396	35	854
12	3,197	36	815
13	3,007	37	778
14	2,825	38	744
15	2,653	39	711
16	2,490	40	681
17	2,338	41	653
18	2,195	42	626
19	2,062	43	600
20	1,938	44	576
21	1,823	45	554
22	1,717	46	533
23	1,618	47	512
24	1,525	48	493
25	1,440	49	475
26	1,361	50	458
27	1,287	55	385
28	1,219	60	327

Example.—Determine the ultimate resistance of a dry northern pine story post 9 inches by 6 inches by 10 feet long, ends fixed. The ratio of length to least dimension is 20 to 1. From the table the value of p is found to be equal to 1,938 lbs. Therefore, 1,938 multiplied by 54 (the number of square inches in area) = 104,652 lbs. For safety, let a factor of ⅕ be taken—

∴ 104,652 × ⅕ = 20,930 lbs. or 9·34 tons nearly.

Technical Terms.—The following are some of the terms used in iron girder construction:—

Clear Span.—The horizontal distance between the abutments.

Effective Span.—The distance between the centres of the bearing surfaces of the girder on the supports, and is taken for purposes of calculation in the event of the camber of the girder preventing the bearing surface of the girder resting on the outer edge of the stone template.

Effective Load.—The effective span in feet multiplied by the weight of the distributed load per foot run.

Bearing Surface.—That part of the lower face of the girder which when loaded rests upon the support.

Total Length.—Is the length to the edge of the bearing surfaces, plus the length of the bearing surfaces.

Effective Depth.—The distance between the centres of gravity of the flanges.

Feathers.—Triangular or circular fillets inserted at the angles of cast-iron girders, etc., where triangular, usually making angles of 135° with the horizontal and vertical faces; right angles in cast-iron are a source of weakness.

Camber.—This is a vertical curve in an upward direction from the bearing points. Beams are cambered to allow for the deflection of a beam when loaded, and to avoid the apparent sagging that exists in all long horizontal lines. Cast-iron girders should have a camber of ¾ inch to every 10 feet of span; wrought-iron and steel girders ½ inch in 10 feet.

Sections of Iron Girders.—The most economical disposition of the material for stress-resisting purposes, is theoretically to place the mass of the material as distant as possible from the neutral plane of the section; practically this condition is nearly satisfied in the I section. In large plate girders the flanges are considered to resist the bending stresses and the web the shearing stresses. In cast-iron girders and rolled joists, the webs for practical reasons are made much larger than the necessary area to resist shearing, and in computing their strength, the value of the inertia of these webs should be taken into account, to obtain the maximum resistance of such girders.

The form and dimensions of girders are often modified according to whether they are fixed or supported only.

Beams are said to be fixed when they are bolted at the ends, or if continued over a number of supports, the parts over the inner spans may be considered as fixed.

Cast-iron Girders.—The best shape for cast-iron beams is that of I section, the tensional flange being four to six times the area of compressional flange.

The depth is usually about $\frac{1}{15}$ the length, and the width of compressional flange $\frac{1}{30}$ to $\frac{1}{40}$ the length.

All castings should vary in thickness gradually, and stiffeners should be cast about every 3 feet apart.

Specification for Constructional Cast-Iron.—The metal should preferably be good soft grey cold-blast iron, sound and clean, cast from the second melting, free from injurious cold shuts or blow-holes, true to pattern, and of a workmanlike finish. Sample pieces, 1 inch square, cast from the same heat of metal in sand moulds, shall be capable of sustaining on a clear span of 4 feet 6 inches a central load of 500 lbs. when tested in the rough bar.

Sharp corners are a source of weakness, and should be well rounded; or triangular fillets, called feathers, cast at all internal angles.

Figures 400 and 401 show section and part elevation of a cast-iron girder used as a beam, supported at the ends, resting on a stone template, the top flange being in compression and the bottom flange in tension.

Figures 402, 403, and 405 are sections of cast-iron girders fixed at both ends, where each flange would at different parts be under tensional and compressional stresses. Of these there are two forms: (1) the I section, as shown in figure 403, and

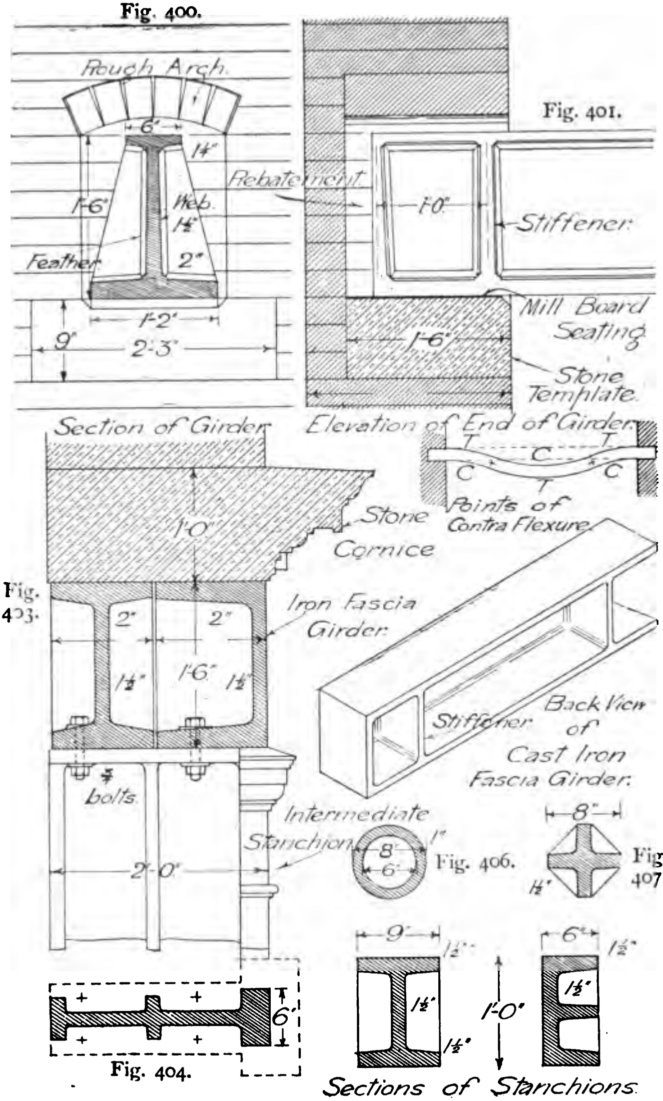


Fig. 400.
Rough Arch.
6"
14"
Rebatement
1-6"
Web.
1½"
Feather
2"
1-2"
9"
2-3"
Section of Girder
Fig. 401.
1-0"
Stiffener.
Mill Board
Seating
1-6"
Stone
Template.
Elevation of End of Girder.
Fig. 402.
T
T
C
C
T
C
Points of
Contra Flexure.
Fig. 403.
1'-0"
Stone
Cornice
Iron Fascia
Girder.
2"
2"
1½"
1'6"
1½"
⅞ bolts.
Intermediate
Stanchion
2'-0"
Fig. 405.
Stiffener
Back View
of
Cast Iron
Fascia Girder.
8"
6"
1"
Fig. 406.
8"
1½"
Fig 407.
6"
Fig. 404.
9"
1½"
1½"
1½"
1'-0"
6"
1½"
1½"
Sections of Stanchions.
Fig. 408.
Fig. 409.

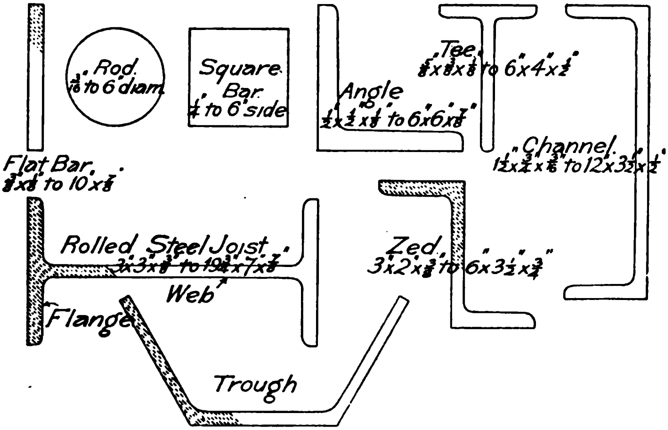
Figs. 400–409.

(2) the channel section; the latter is used extensively in Scotland as bressummers over shop fronts, as shown in figures 403 and 405.

Figure 405 is an isometric view of the cast-iron channel section girder, showing the position of the stiffeners.

Figure 402 is a diagram showing the points of contrary flexure and the undulating curved outline of the flanges of a girder, fixed at both ends when stressed by a central load.

Cast-iron Stanchions.—Figures 406 to 409 show sections of four forms of cast-iron stanchions. Figure 406 shows the circular section used where the column is exposed. Figure 407 is the cross section, used largely where stanchions are to be covered with faïence-ware or terra-cotta. Figure 408 shows the **I** sections, where stanchions are to be surrounded by brick; and figure 409 shows the ribbed channel form, used against party walls for supporting bressummers over shop fronts.


Rod. 3/16" to 6" diam.
Square Bar. 1/4" to 6" side
Flat Bar. 3/8"x1/8" to 10"x7/8"
Angle 1/2"x1/2"x1/8" to 6"x6"x7/8"
Tee. 5/8"x3/8"x1/8" to 6"x4"x1/2"
Channel. 1 1/2"x3/4"x3/16" to 12"x3 1/2"x1/2"
Rolled Steel Joist. 3"x3"x3/8" to 19 3/4"x7"x7/8"
Web
Flange
Zed. 3"x2"x3/8" to 6"x3 1/2"x3/4"
Trough

Figs. 410—418.

Cast-iron girders and stanchions are not considered as reliable as those of wrought-iron or steel, as they may contain serious flaws hard to detect, and do not equally well withstand sudden changes of temperature. Cast-iron girders have snapped suddenly when cold water has been thrown upon them while they have been in a heated state, as often happens in a burning building.

Wrought-iron and Steel Girders.—Owing to the improvements in the manufacture of wrought-iron and steel, girders are now almost exclusively made of these materials. Wrought iron and steel are rolled to numerous sections, as shown in figures 410 to 418, which can be readily adapted to any of the requirements of construction. Cast-iron girders were first largely displaced by wrought-iron girders, and now the latter have been superseded to a very great extent by steel. Heat causes wrought-iron and steel to expand considerably, for which reason girders of these materials should never be fixed at both ends.

The following table shows the relative strengths in tons of cast iron, wrought iron, and steel, as most commonly used in ordinary construction:—

	Tension.	Compression.	Shearing.
Cast Iron	7 to 8	40 to 45	12
Wrought Iron ...	22	16 to 17	22
Steel	30	30	24

Wrought-iron crushes with an average of 17 tons, and fails in tension with a pull of 22 tons. In practice, for small beams this difference is disregarded, and joists are rolled with two equal flanges, which can be easily obtained to a depth of about 20 inches. Figure 416 shows section of a rolled iron or steel joist.

Many forms of composite girders are constructed by riveting plates to the flanges of rolled iron and steel joists.

Plate Girders.—For deep girders it is considered more eco-

Fig. 419.

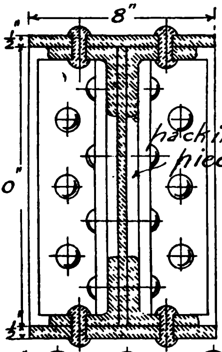


Fig. 420.

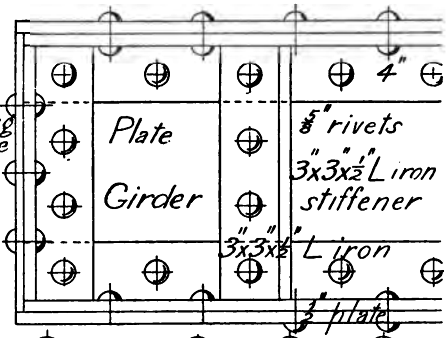


Fig. 421.

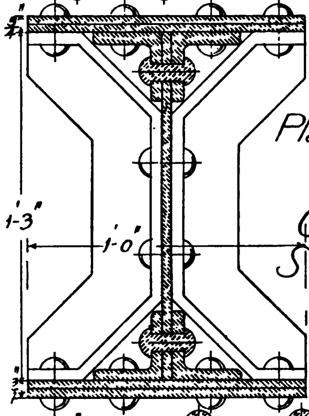


Fig. 422.

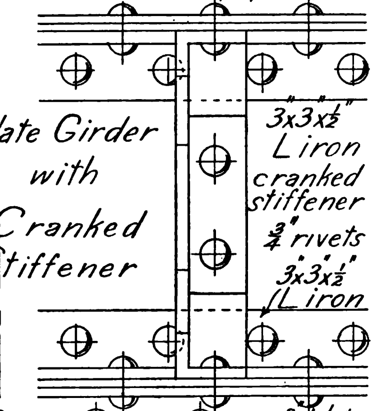


Plate Girder with Cranked Stiffener
3"x3"x½" L iron cranked stiffener
¾" rivets
3"x3"x½" L iron

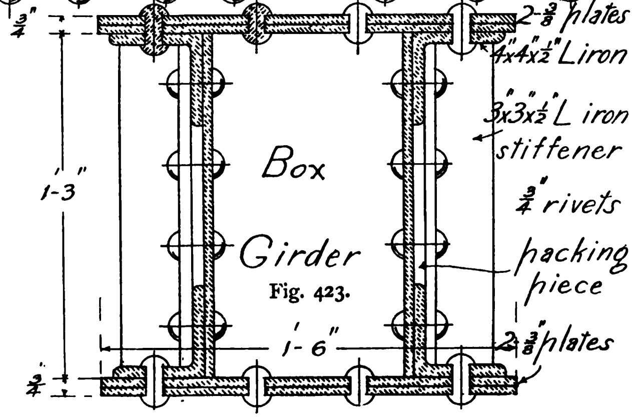


Fig. 423.

Figs. 419–423. Plate and Box Girders.

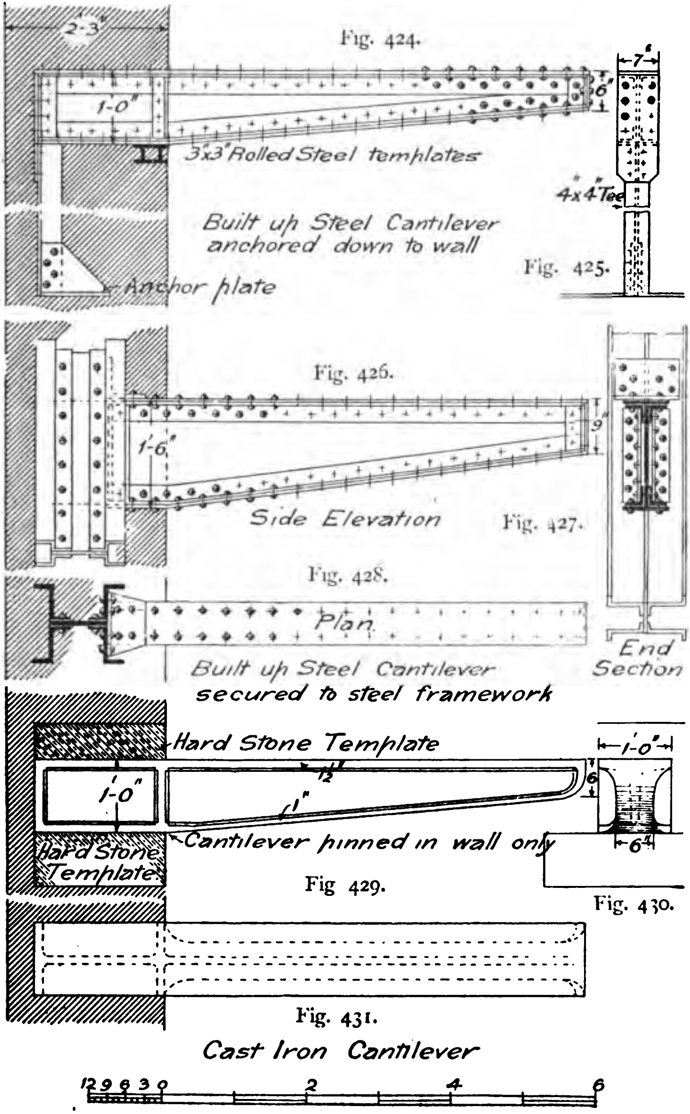
nomical to build them of riveted plates, angles and T irons, and to strengthen the webs and flanges with stiffeners of T or angle irons. Stiffeners may be simply angle or tee irons, cut to fit and riveted between the flanges and against the longitudinal angle irons, a level surface being made with the latter; a vertical packing piece having a width equal to the stiffener and of the thickness of the longitudinal angle irons. Figures 419 and 420 show section and part elevation and illustrate the fixing of end plates.

Figures 421 and 422 show section and part elevation of plate girder with cranked stiffener, used where wide flanges are necessary.

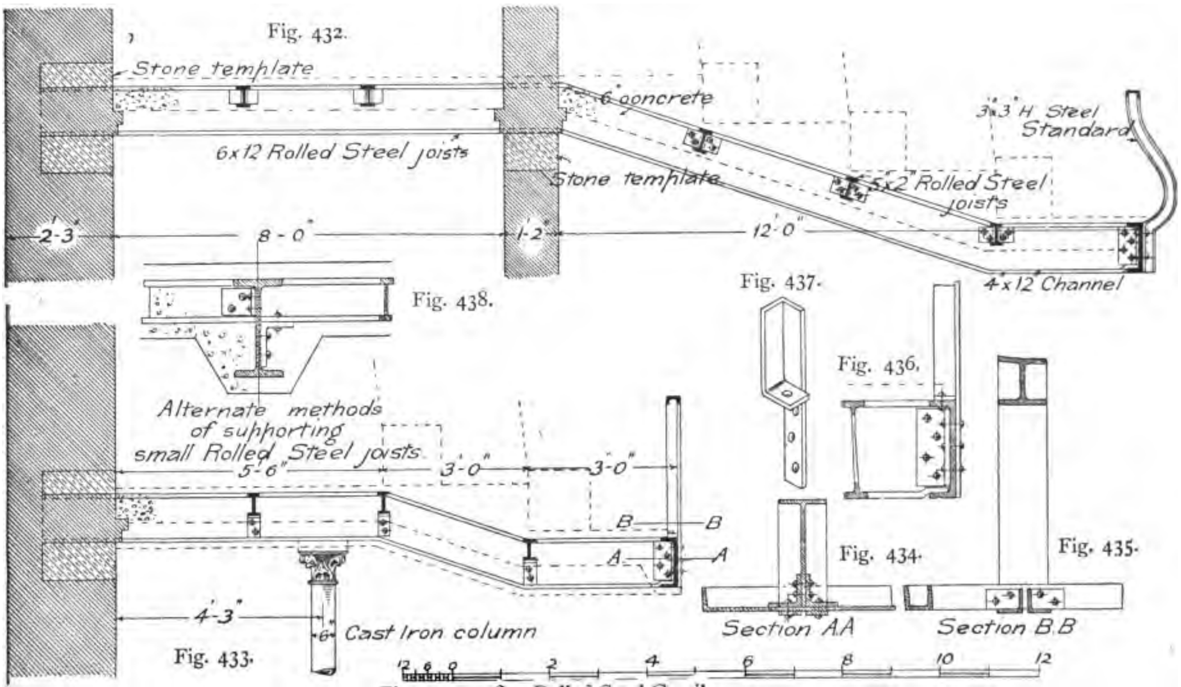
Box Girders.—Where girders are required with extra wide flanges, such as a girder carrying a thick wall, they may be constructed with two webs. These are stronger than plate girders of equal section, and not so liable to twist laterally, owing to the greater support offered them by the webs. Figure 423 shows this method.

In large box girders used externally either the end plates should be bolted to the body of the girder, or a manhole should be arranged in the web, for the purpose of painting the inside.

Semibeams or *Cantilevers.*—Beams fixed at one end only, and free at the other, are used to support projecting galleries. Owing to the tendency of these semibeams to act as levers and tilt or overturn the wall above, they are termed cantilevers. The overturning action may be resisted: 1st, by placing a great weight over the fixed end, or, better, by tying the end down with anchor-plates and ties as shown in figures 424 and 425. This latter method is preferable to the former as it prevents internal stresses in the upper portion of the wall. The internal bearing edge is under a great compressive stress and is liable to fracture, to avoid which the ordinary stone template is now replaced by rolled steel joists of small section, as shown in figure 424. Figures 426 to 428



Figs. 424–431. Steel and Cast- Crc nantilevers.



Figs. 432–438. Rolled Steel Cantilever.

show a built-up steel cantilever as used in modern steel skeleton construction. The web of the cantilever is usually carried right through, and in that part forms the web of the stanchion. The cantilever is securely riveted to the stanchion which renders it independent for its stability upon the stone or brick casing. Figures 429 to 431 show an ordinary cast-iron cantilever depending on the superincumbent load for its stability. The bottom flange being under a compressional stress is smaller in section than the top flange, but must be widened out at the bearing edge of the wall to avoid the crushing of the template beneath. It is necessary to have a template above as well as beneath in cantilevers fixed in this manner.

Figure 432 shows the arrangement of the rolled steel cantilever suitable for a public hall where there is an adjacent corridor; the internal wall acting as the fulcrum and the outer and tailing wall acting with the leverage of the width of the corridor. The girder is cranked to enable the seats to be arranged in tiers one above the other. The outer ends of all cantilevers are connected by channel iron; the standards for the balustrading is formed of **H** iron riveted to the channel iron at the required intervals, and the upper ends of the standards are connected by channel iron to which the wood handrail is fixed. The floor is formed of 2" × 5" steel joists, riveted at intervals to the main cantilevers, the spaces between being filled with concrete.

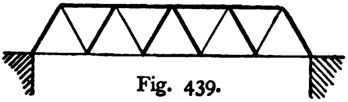


Fig. 439.

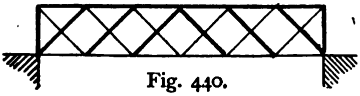


Fig. 440.

Figures 433 to 438 show the arrangement where there is no adjacent corridor, and where it is desirable there should be no columns beneath the outer edge of the gallery to obstruct the view. A series of columns is placed under the canti-

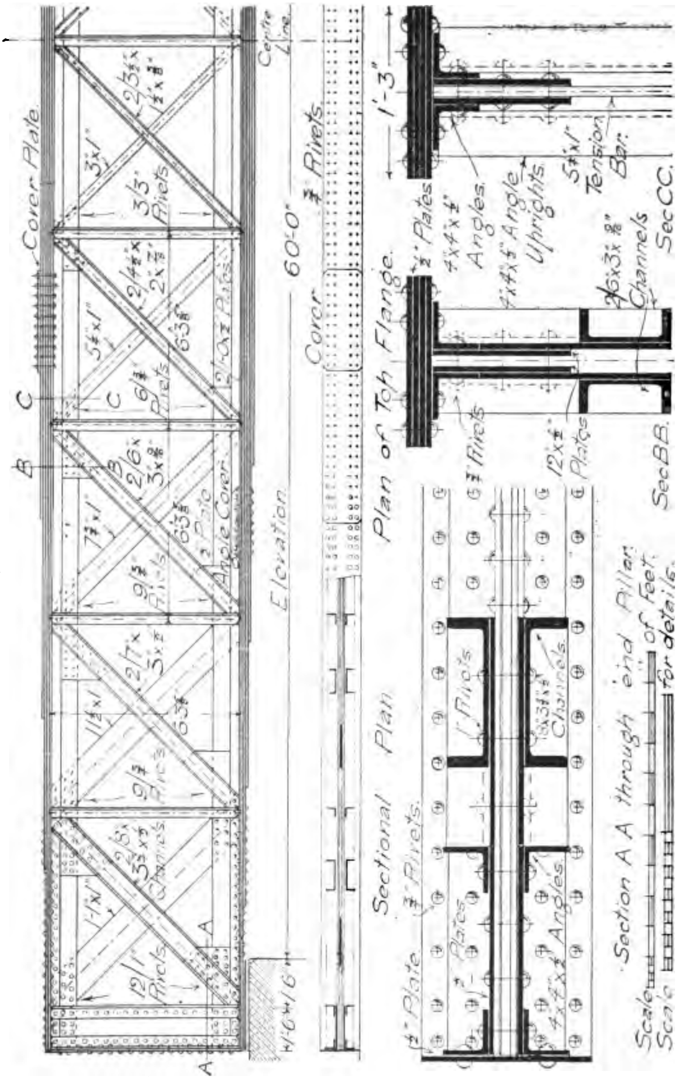


Fig. 441.

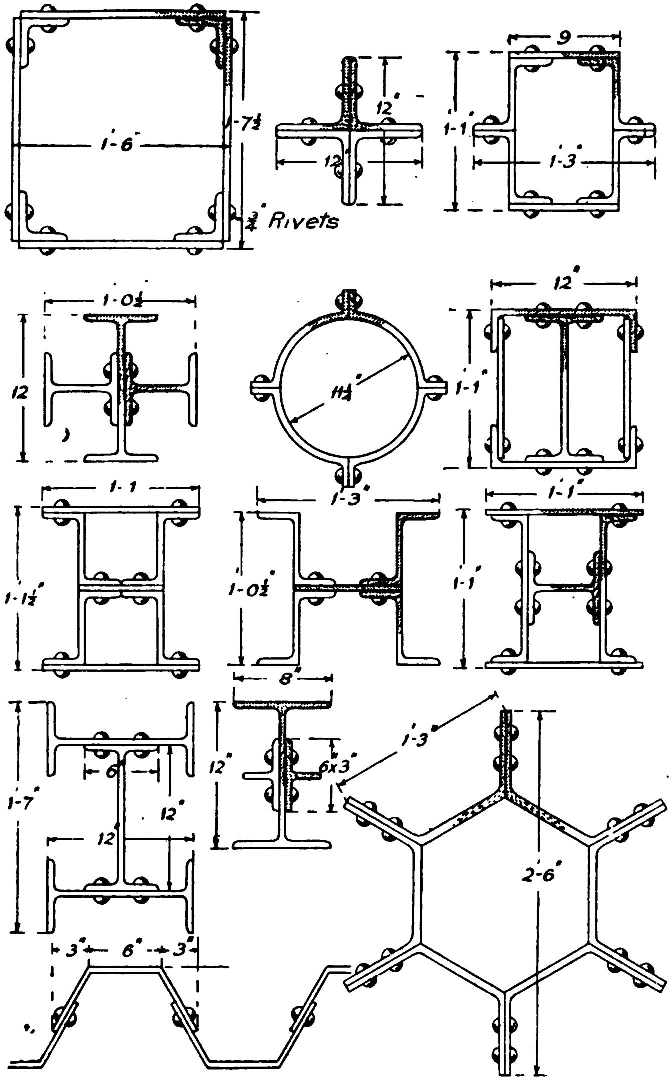
Fig. 442.

Fig. 443.

Fig. 444.

Fig. 445.

Figs. 441—445. Steel Latice Girder.



Figs. 446–458. Sections of Stanchions.

levers at a distance from the wall sufficient to form a convenient gangway.

Warren and Lattice Girders.—Where great depth in girders is no objection, as in bridges, they are often made on the principle of the truss, where by giving them increased depth the material may be economised. Figures 439 and 440 show line diagrams of types of the Warren and Lattice girders, in which the web plates are replaced by bars and angle irons riveted together

Fig. 463. Fig. 464.

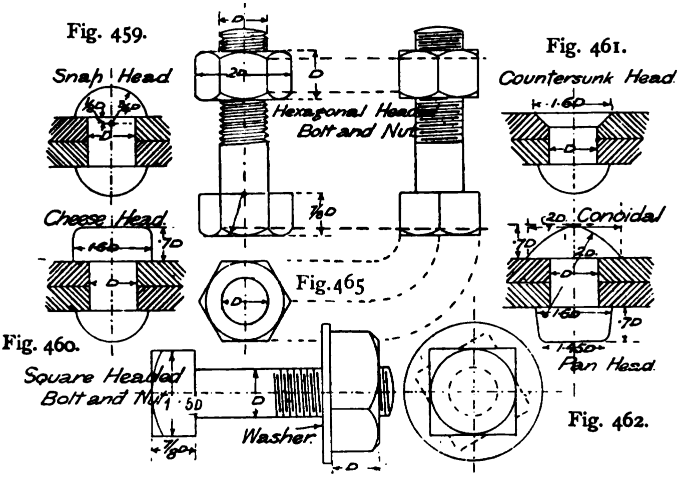


Fig. 466. Fig. 467.

In these figures, when the girders are uniformly loaded on the upper flange, the thick lines indicate the members in compression and the thin those in tension. The compressional members are termed "struts," and are usually made of angle, tee or channel irons; the tensional members are called "ties," and are of bar-iron. The vertical members joining the horizontal members, sometimes used in lattice girders between the apices of braces, serve to transmit the load in such a manner that one half of the load immediately above is carried by the top flange and the other half by the lower. These vertical members are formed by angle, tee, or channel irons, according to the size of the girder. The horizontal members of braced girders are termed booms, and are constructed of plates and angle irons in a manner similar to that of ordinary plate girders.

Iron sections framed as isosceles triangles, arranged in one system and bolted or riveted together to the form shown in figure 439, are known as Warren girders.

Figure 440 is an outline of a girder composed of two systems of triangles traversing each other, and is known as the lattice girder.

More than two systems of triangles may be arranged.

Figures 441 to 445 show a steel lattice girder of 60 feet span designed to support a distributed load of 3·6 tons per foot run, loaded on the bottom flange, and having upright bars to distribute the load equally upon both flanges, with details showing sections and connections of the various parts.

Stanchions.—Figures 446 to 458 show steel sections built up into stanchions; all systems of rectangular sections lend themselves to be encased with brickwork. The circular and polygonal sections are best adapted for being encased with terra-cotta or faience ware to form circular columns. Open sections are best for exposed stanchions, as all of the parts are accessible for painting.

Rivets.—Figures 459 to 462 show forms of the following rivet heads:—snap, cheese, countersunk, conoidal and pan; all parts of each rivet are given in terms of the diameter of the shank. For constructional purposes the snap or cup head is ordinarily used, the countersunk where a flush surface is required.

The rivet holes in steel plates up to ½ inch in thickness are usually punched; plates ½ to ¾ inch are punched and rymered or annealed afterwards, above ¾ inch they are drilled. Punched holes being slightly tapering afford a better grip for the rivets, but tend to weaken the plates, see Part II.

Bolts.—Figures 463 to 467 show the hexagonal and square headed bolts, all the parts being given in terms of the diameter of the shank.

CHAPTER V.

JOINTS IN CARPENTRY.

Stress and Strain.—Stress is the name given to an external force acting upon material, and is measured per unit area in gravitation units as lbs., cwts., etc.; strain is the amount of deformation of such material, and is measured either by the perpendicular distance of the axis from its original position, or by the proportionate reduction or elongation in length.

Beams are said to be in tension when subjected to a length-stretching or pulling force, as in the case of a tie-beam, and all members wholly in tension may be considered as ties.

Beams subjected to a crushing or pushing force are said to be in compression, as in a short pillar, and all members in compression may be considered as struts.

If a load or pressure be applied at right angles to the length of a beam it will cause a bending or cross strain, as when a floor joist is carrying weight. It may be noticed that the tendency of the upper part is to become hollow or concave; such fibres are in compression, and the lower in tension. Somewhere between the two will exist fibres neither in tension nor compression, and the plane containing these fibres is known as the neutral layer, or the layer under no stress, which in a theoretically perfectly elastic material would be in the centre of the section.

If a force acts with a twisting or wrenching tendency, the piece stressed is said to be in torsion; such stresses do not frequently occur in structural woodwork, but in screws and in parts of machinery.

Shearing is a cutting or sliding stress; but in woodwork, when the force shears the beam in the direction of its fibres, it is more particularly described as detrusion, as in the case of the foot of a principal rafter causing the end fibres of tie beam to have a tendency to slide along the grain, thus leaving shearing stress to imply that the force acts at right angles to the grain, as in the example of a loaded beam at the points of supports where the shearing stress is the greatest.

Designing Joints.—In designing joints, the following principles, based upon those suggested by Professor Rankine, should be considered:—

1. To cut the joints and arrange the fastenings so as to weaken as little as possible the pieces of timber that they connect.
2. To place each abutting surface in a joint as nearly as possible perpendicular to the pressure which it has to transmit.
3. To form and fit every pair of surfaces accurately, in order to distribute the stress uniformly, and to proportion the area of each surface to the pressure it has to bear, so that each part may be safe against injury.
4. To proportion the fastenings so that they may be of equal strength with the pieces which they connect.
5. To place the fastenings in each piece of timber so that there shall be sufficient resistance to the giving way of the joints by the fastenings shearing or crushing their way through the timber.

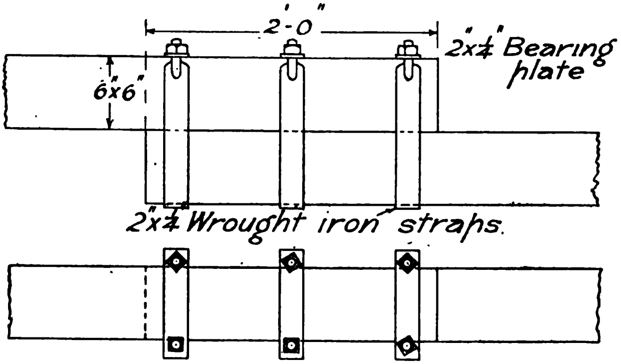
Classification of Joints.—Joints may be arranged under the following heads:—

a. Lengthening Joints.—Lapping, fishing, tabling, scarfing, building up.

b. Bearing Joints.—Notching, cogging, halving, dovetailing, housing, mortice and tenon, chase mortising, joggle, tenon, housed and dovetailed tenon, tusk tenon, foxtail wedging, bridle.

c. Oblique Shouldered Joint.—Mitre, birdsmouth, halving and dovetailing, oblique tenon, single abutment, bridle.

Lengthening of Beams.—Beams may be lengthened in various ways to suit the particular stress the timber has to resist



Figs. 468, 469.

This is rendered necessary if the desired length is not obtainable in the market.

Lapping consists in resting the end of one piece on the end of another piece, and securing the same with bolts if to resist tension; if compression, straps, as in figures 468 and 469, or as in scaffolding by ropes and wedges. This joint has a clumsy appearance, and should be used only for temporary structures.

Where the ends are required to be level, the length should be composed of an odd number of pieces.

Fishing.—Two pieces of timber having their ends abutting, with a plate of wood or iron secured on two parallel sides by means of bolts, are said to be fished, as in figures 470 and 471.

For the lengthening of beams, a plain fished joint is most economical for labour and material. In the event of the timbers shrinking, and thus causing great stress upon the bolts, coincident grooves are cut in the pieces joined, and the fish plates and keys of hard wood or folding wedges inserted to assist the bolts, as shown in figure 473; or sometimes tabling is resorted

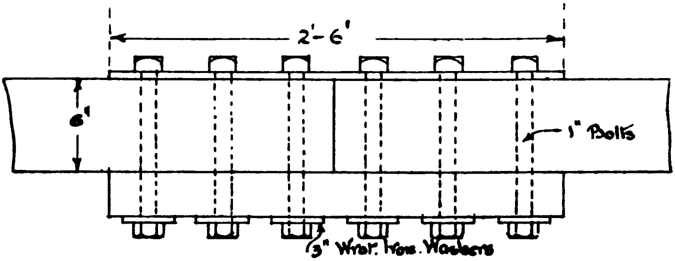


Fig. 470.

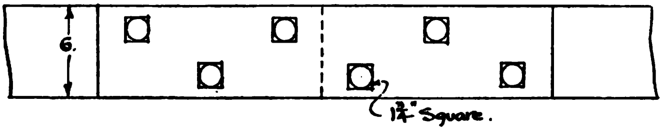


Fig. 471.

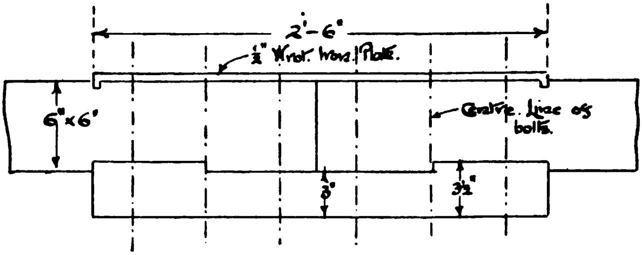


Fig. 472.

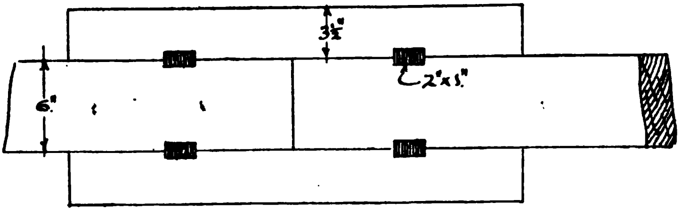


Fig. 473.
Figs. 470–473. Fished Joints.

to, as in figure 474, by bedding portions of one beam into another; but as this is costly, and reduces the effective section of the beam, it is not often employed. Where iron fish plates are employed, the ends are turned in, as shown in figure 472. In designing a fished joint, the following rules, *based* upon those given by Seddon, should be observed:—

1. The strength of fished joints depends on the effective sectional area of fish plates, being together equal in tensile strength to the effective sectional area of the tie.

2. On the sectional area of the bolts on either side of the joint being sufficient to resist shearing. Let the ultimate compressile, tensile, and shearing resistances of wrought iron be taken as 36,000, 49,000, and 49,000 lbs., and the ultimate compressile, tensile, and shearing detrusion resistances of good fir be taken as 5,000, 4,000, and 600 lbs., respectively per square inch of area opposed to force, then the shearing strength of wrought iron is to the tensile strength of fir as 49 is to 4, or, approximately, 12 to 1. Therefore the shearing area of the wrought iron should be one-twelfth the net tensile area of beams joined; that is, in members connected by a fished joint, subjected to single shear with one plate only, the sum of the sectional area of the bolts on each side of the joints should equal one-twelfth the net tensile area of the timber joined; with fished joints with two plates (the usual practice), this being subjected to double shear, the sum of the areas of the sections of the bolts on each side of the joint should equal one-twenty-fourth the net tensile area of the timber joined. Generally, in any joint connected by bolts, the number required may be ascertained by making the sum of the minimum sectional areas opposed to the shearing force, which on shearing would cause failure of joint, to equal in area one-twelfth the net tensile area of the timber.

3. On the placing of the bolts in such a way, and at such distances from the ends of the timbers, as to prevent their drawing through them.

4. The bearing area of the bolts must be sufficient to

prevent their cutting their way through either the timbers or the fish plates.

Scarfing and *Fishing.*—The following difference may be noticed between a fished and scarfed joint.

In the fished joint the total length of pieces joined is not reduced, while in the scarfed joint the pieces are cut and fitted over each other so as to keep the same breadth and thickness throughout, the total length of pieces joined only being less than the sum of the separate lengths, by the length of the scarf.

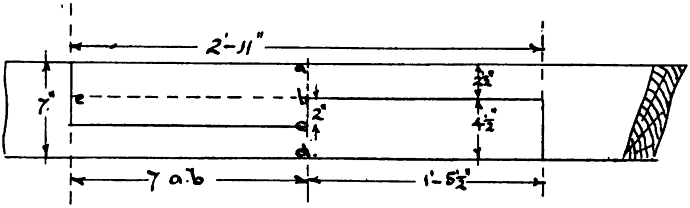


Fig. 474.

Scarfing should be used for the jointing of timber in the direction of its length, if neatness be necessary as well as strength.

Figure 474 shows a tabled joint, and if this be calculated as shown, dimensions for other scarfs may be reasoned out in a similar manner.

If area expressed by $b\ c$ yields, the joint fails under compression; should $a\ b$ or $c\ d$ rupture, the joint fails under tension. By equating, it will be found for fir compressional area required is four, when the tensile area is five.

$\therefore\ b\ c$ = compressile area = $\frac{4}{14}$ depth of beam.

$a\ b = c\ d$ = tensile area = $\frac{5}{14}$ depth of beam

$b\ e$ is the area opposed to detrusion for fir; by equating, it will be seen that the necessary area should be $\frac{40}{6}$ of the tensile area, or approximately the detrusion area must be seven times the tensile area.

The lengths of scarfs may then bear the following proportion to depth :—

Length = $14 \times \frac{5}{14}$d. = 5times depth $\left\{ \begin{array}{l} \text{Without the assistance of} \\ \text{iron bolts.} \end{array} \right.$

When the scarf is assisted by bolts and fish plates the strength of the joints may be made equal to the strength of the net tensile area of the timber; that is, if there are two lines of bolts in the plan, the sectional area will be reduced by the sum of the sectional area of fibres cut by two bolts. The length of the scarf may vary between three times the depth and zero times the depth, in which latter case it practically becomes an ordinary fished joint.

Figures 475 to 478 show two forms of joints to resist tensional stress. Figures 475 and 476 show a scarf constructed by tabling, tongued at ends, and secured by hard wood keys and wedges. Figures 477 and 478 show a simple form of scarf made by halving, tongueing, and tightening up by wedged keys. The shearing area along BF to be at least seven times BC, and BC should equal $\frac{5}{4}$ times the sum of the depths of the keys.

Building Up.—Curved ribs of domes, roofs, centres and standards of derrick crane towers, and the booms of trussed timber girders, may be economically built up as shown in the "Advanced Course" of this work.

Figures 483 to 488 illustrate a laminated arched rib, used as the supporting member of a timber bridge for a span of 60 feet.

The rib is constructed of six laminæ, each 3 inches thick, bent about a curve of 35 feet 9 inches radius. The ends are secured in cast-iron shoes, built into the abutments at each end. The laminæ are secured together by two rows of $\frac{3}{4}$-inch wrought-iron bolts spaced 2 feet apart. The joints in the laminæ are spaced at equal distances apart, say 8 feet, and not more than one joint in any cross section. The advantages of this method of building up over that by means of the

Fig. 475.

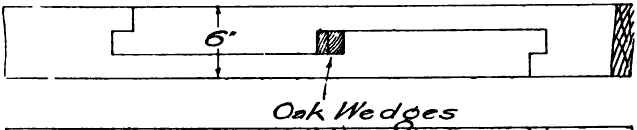


Fig. 476.

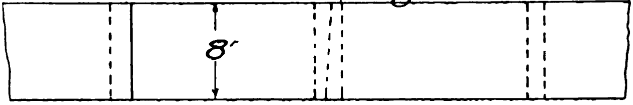


Fig. 477.

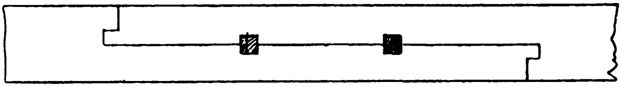


Fig. 478.

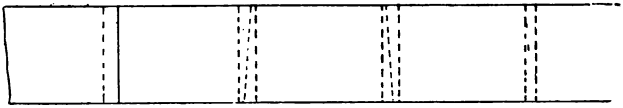


Fig. 479.

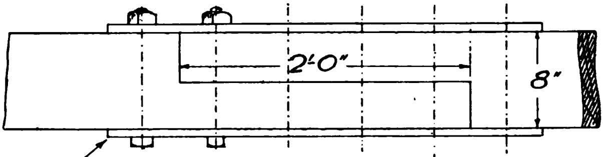


Fig. 480.

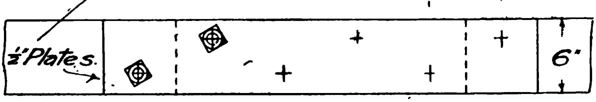


Fig. 481.

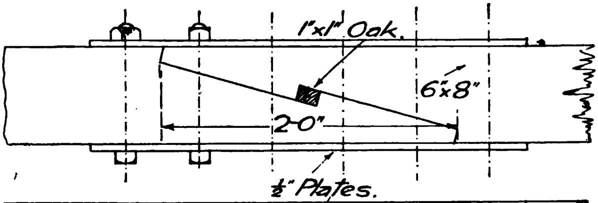
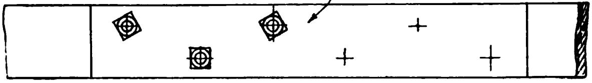
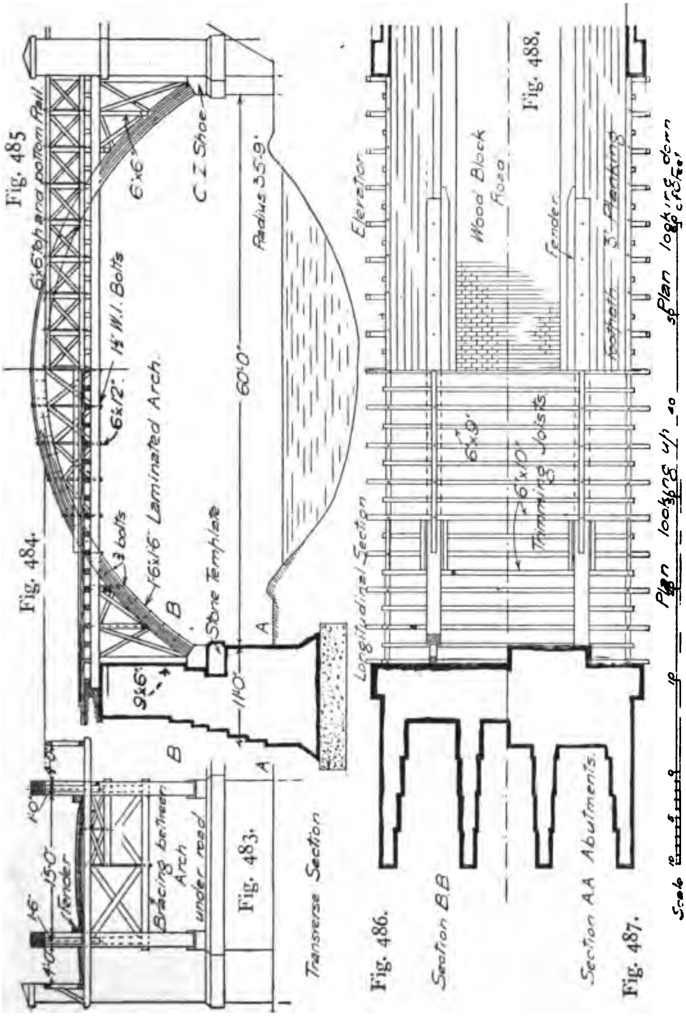


Fig. 482.



Figs. 475–482. Scarfed Joints.

vertical laminæ are: 1st, the comparatively small number of joints; and 2nd, the continuity of the grain is uninterrupted.



Figs. 483-488. Timber Bridge with Laminated Arched Rib.

The strength of such a rib may be considered equal to a solid rib with an equal depth, but of a thickness equal to the sum of the thicknesses of the separate pieces minus one.

To support the roadway of this bridge, 6" × 12" timbers are built into the arched ribs, and pass through the centres of the latter. The loads are transmitted to the arches at their haunches by means of upright struts from the underside of the beams to the top of the arches. The central portions of the beams are supported from the crowns of the arches by means of bolts, the spaces between the bolts and between the struts are cross braced, as shown in figure 484: this makes the ribs rigid, and together with the abutments prevents any tendency of the arched ribs to spring back to the straight. At the haunches the ribs are cross braced under the roadway, as shown in figure 483.

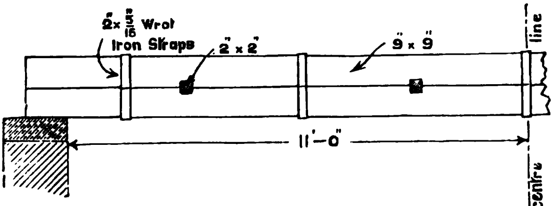
The roadway is supported by 6" × 9" cross beams, these projecting beyond the rib at each end to form the footpath. To give the necessary rise to the centre of the road, curved furring pieces are nailed on these timbers; the whole is then covered with 3-inch planking, and, upon this planking, wood blocks set in pitch are laid to form the road surface. The ribs are protected from vehicular traffic by means of stout timber fenders. The balustrade for the footway is fixed on the projecting beams, and is kept in the vertical position by inclined stays supported by every alternate beam, as shown in figure 483.

Figures 481 and 482 show the form of scarf which, assisted by bolts and fish plates, is most commonly used in practice to resist tensional stress: the simplicity, easiness of fitting and putting together by means of oak wedges render it a suitable and efficient joint for the purpose, the resistance to the shearing stress being offered by the wrought-iron bolts.

Scarfs to Resist Compression.—For joints to resist compression the abutting surfaces should be perpendicular to the pressure, consequently, all shoulders should be square, and no splayed sallys or internal angles should be allowed. The following are suitable:—Scarfs similar to those shown in figures 475 to 478. The method shown in figures 479 and 480, formed by halving the timbers, with iron plates and bolts, is the simplest and most effective if plates and bolts are permissible.

Transverse Stress.—Wherever the span to be bridged is too great to admit of the use of timber in one piece, the beam employed should be trussed, so that every member may be under a direct length stress, as the joints that have been designed, although ingenious and costly, are not satisfactory.

Fig. 489.



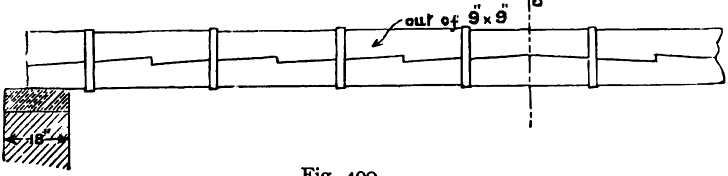


Fig. 490.

Figure 489 shows a method of building up, and is applicable to resist a transverse stress by placing one timber directly on the other, to obtain a deeper beam than could be readily obtainable in one piece. To resist the horizontal shearing stress, hard-wood keys, with the grain at right angles to the stress, are inserted. The timbers are held together by iron collars or straps, bolted as shown in figure 489.

Another method of obtaining the same result is by forming the joint between the two members by a series of indents, and joining by iron collars or straps, bolted, taking care to arrange the shoulders of the indents, as shown in figure 490, to resist the compressional stress caused by the upper piece tending to slide over the lower.

Notching.—Joists resting on wall plates are commonly notched, as shown in figures 491 and 492, for the purpose of bringing all the upper surfaces to a required level, the shoulders assisting in forming a fixing and in keeping the work square. The plate should be housed in the case of joists, as shown in figure 495, to obtain a bearing for the whole depth of the joists.

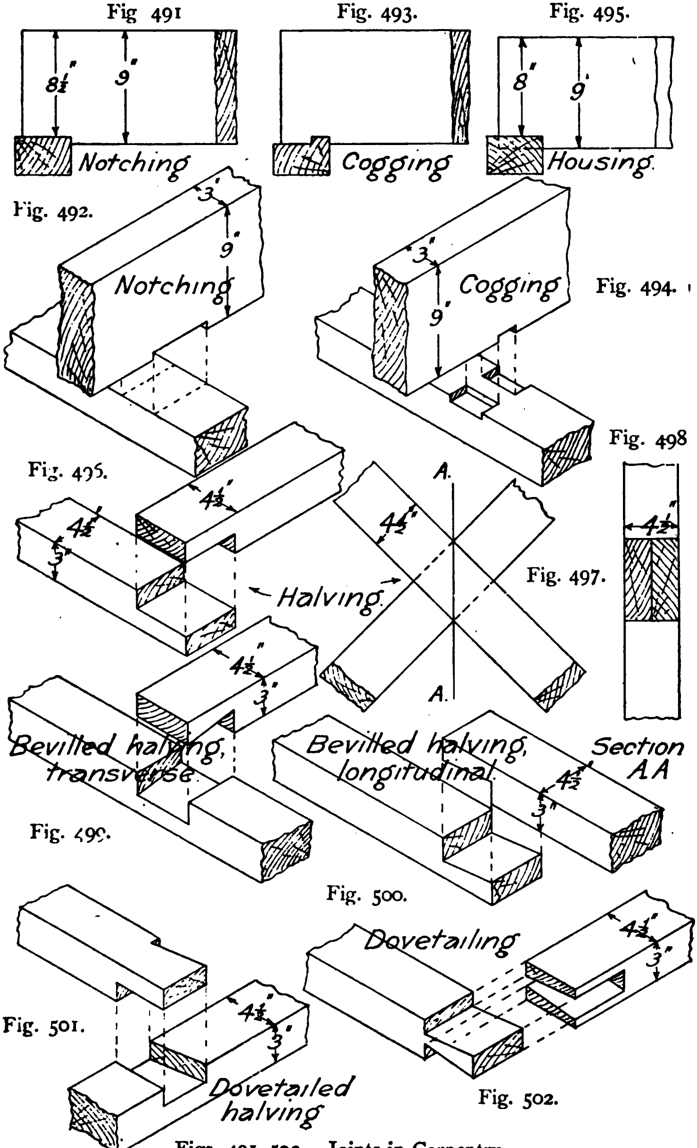
Cogging.—Where wall plates, purlins, rafters, or other timbers have timbers crossing them, and it is desired to utilize the entire bearing depth of the timber, and to tie the lower other than by the fastenings, which often consist only of spikes, the pieces may be cut and fitted as in figure 494, two cheeks of rectangular section being taken out of the lower piece, and the upper member having a sinking to correspond to the projection left on the lower piece; this method is termed cogging. Where the end of the joist does not project over the plate it is advisable to form the cog nearer to the edge of the plate, as in figure 493, to obtain the greatest amount of shearing area behind the cog, as the section of the bearing surface has usually an excess of strength.

Halving.—Timbers that cross each other, and are required to be flush on one or two faces, and have a similar sinking in both to fit each other, are said to be halved together, and may be cut as ordinary bevelled or dovetailed halving.

1st. Ordinary halving, as in figures 496 to 498, is suitable for wall plates or braces of partitions crossing each other.

2nd. Bevelled halving, which assists in holding pieces together when spiked, as shown in figures 499 and 500.

3rd. Dovetailed halving is used where one member is to act as a tie for wall plates, as in figure 501; but as the dovetails



Figs. 491–502. Joints in Carpentry.

are usually made of great width in carpentry the pieces shrink, and the joint becomes loose, and fails for the purpose for which it was intended.

Dovetailing.—The joints of the angles of such timbers as curbs, pole plates, etc., which are usually deeper than the ordinary wall plate, are dovetailed as shown in figure 502.

Housing.—When the entire end or thickness of a piece of timber butts and fits into another piece, it is said to be housed. This joint is used for heavy work where other methods would be weak or expensive. The pieces joined would be secured by bolts, straps, tenons and wedges or dovetailing as in figures 509 to 512, or other fastenings.

Mortice and Tenon.—For simplicity of construction and efficiency for its purpose, the mortice and tenon joint is pre-eminently good; and is undoubtedly in some form or other used more than any other kind of joint.

Ordinary Mortice and Tenon.—The end of a piece of timber is cut so that a projection or tenon is formed which has a thickness ⅓ that of the material; the adjoining piece is mortised to correspond to the tenon, and the latter may be secured either by wedges from the back, as in figure 503, by dowel pins from the faces as shown in the chapter on Joinery, or wedges and dowels may be combined for purposes of strength.

Chase Mortices.—Wherever it is required to fix timbers between the main timbers, which are already secured and immovable, the method of chase mortising may be adopted, which consists in fitting one end in the ordinary manner, and in the other main timber the mortice to receive the other extremity is cut as illustrated in figure 505, to allow the tenoned member to revolve into its ultimate position, that end which is fitted into the ordinary mortised main timber being used as the

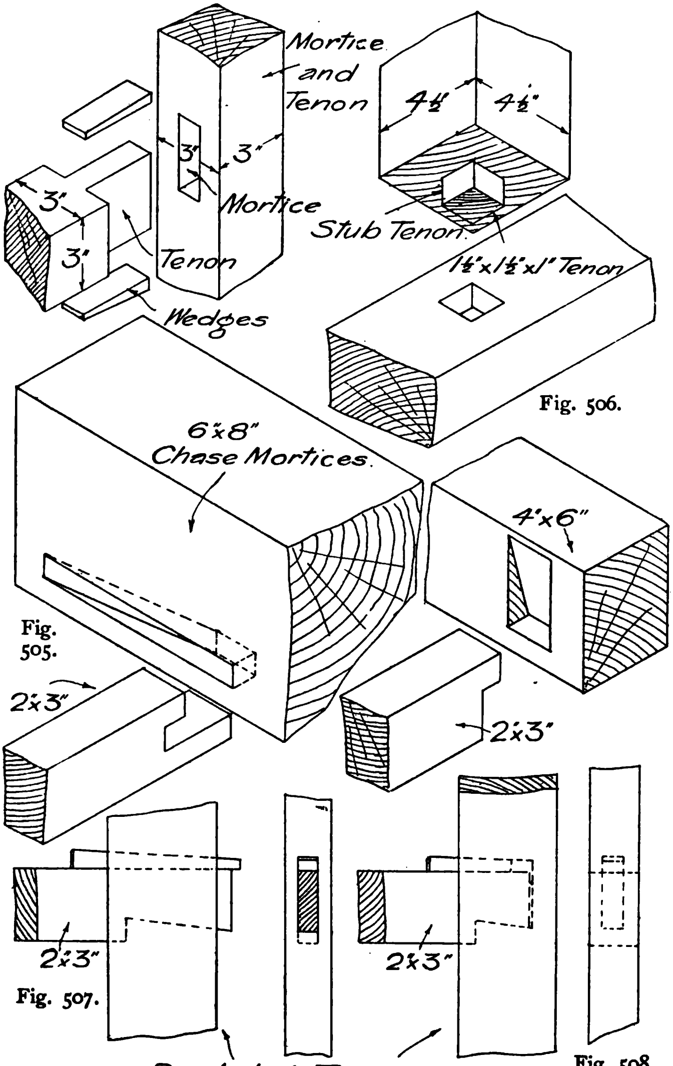


Fig. 503.

Fig. 504.

Fig. 505.

Fig. 506.

Fig. 507.

Fig. 508.

Figs. 503–508.

centre. The same purpose may be accomplished by cutting a vertical groove, as in figure 506, to allow the tenoned member to drop into its place; but by this method fibres are cut, which are not necessarily severed for the mortice, and so its strength is reduced. The better system is to make the horizontal chase, which has the advantage of not unnecessarily reducing its tensile strength. Ceiling joists in double and double framed floors are often fixed in this manner, and instead of cutting away a triangular piece for each joist, a rectangular groove in section, as shown in figure 505, is cut between mortices in every other space between the joists. To prevent any weakening of the binder a fillet is often fixed and the ceiling joists slotted. Both methods are shown in figure 564.

Joggle, *Stub*, or *Stump Tenon* are the names given to a short tenon. It is more particularly known as a joggle when cut, as shown in figure 504, which is used to prevent the foot of a post sliding away from its sill.

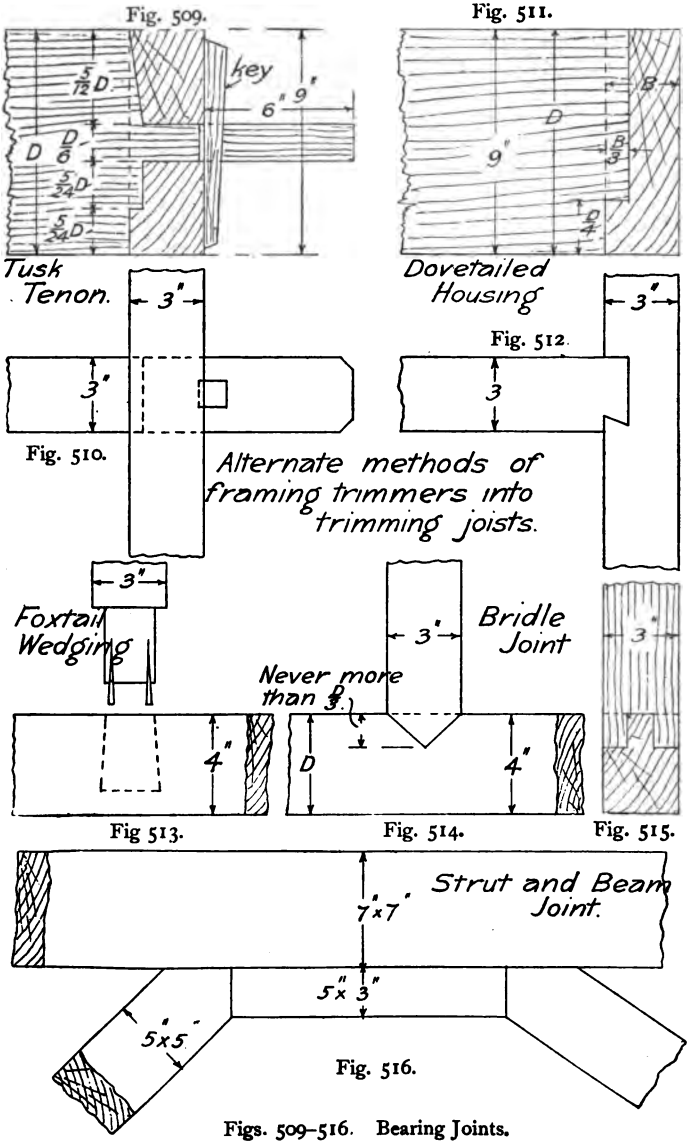
Tenoned and Housed Joints.—For purposes of bearing strength, where the ordinary tenon might not be sufficient, the rail is housed a short distance into the post or style, and tenoned in the usual manner. Figure 591 shows this joint, and the shoulders pulled closely together by means of a key.

Dove-tailed Tenon.—Where two pieces are required to be held together by a mortice and tenon, and to be taken apart occasionally, the tenon may be cut dovetail shape and the mortice made long enough to permit the wide part of the tenon to pass through, and when in this position it is secured by a hard-wood wedge, as in figure 507. This method may be adapted to secure pieces together, as shown in figure 508, when the back edge is not to be cut or is inaccessible.

Tusk Tenon.—Where floor timbers of equal depth are framed into each other it is desirable that the loss of strength should be as little as possible, and yet the members joined must be securely held together. The best bearing joint complying with these conditions is the tusk-tenoned joint. The tenon should be placed in the centre of the depth of the pieces joined, for two reasons. First, when it is in that position the stress caused by driving the wedge draws up both top and bottom shoulders equally tight. Secondly, the best position for the mortice is theoretically in the compressional fibres immediately adjoining the neutral layer, and in good specimens of northern pine timber beams, supported at both ends under loads, the ratio of the resistance of compressional to tensional stresses varies from 3 to 5 respectively in some specimens, and as given on page 137, from 5 to 4 respectively in others; the neutral layer would then vary as calculated by the principle of the moment of inertia (as stated in my *Advanced Course*) from ·45D to ·52D measured from the bottom layer of a rectangular beam, therefore it would be unwise to sink the mortice any nearer to the bottom than $\frac{10}{24}$D as shown in figures 509 and 510. It would be slightly stronger if the underside of mortice were $\frac{12}{24}$D from the bottom layer, though the latter arrangement would make it much more difficult to obtain a tightly fitting joint in timbers that have a tendency to be in winding. The depth of the tusk may be $\frac{5}{24}$D of the depth, that is, one half of the distance between the under surfaces of tenon and joist, and the thickness of the tenon $\frac{D}{6}$, as shown in figures 509 and 510.

In cases similar to binders tusk tenoned to large girders, especially wherever the tenons of two binders are arranged exactly opposite, the tenons of the former do not pass through the entire section of the latter, but only penetrate 3 or 4 inches, and are then spiked with large iron nails or secured with oak dowel pins or trenails, the aim being always to reduce the section of the main timber as little as possible.

Figures 511 and 512 show the method of trimming by the use of the stopped dovetail, a method which is largely employed in the North of England, and is especially applicable in positions where a member can only be conveniently dropped in from above.



Figs. 509–516. Bearing Joints.

Foxtail Wedging.—A method of securing timbers, as shown in figure 513, where the back edge of the mortised member is inaccessible. It is mostly used in joinery work for securing the parts of framing, as in the rails and styles of doors in high-class work, in which the end grain of the tenon would be unsightly.

The mortice is sunk to from ½″ to 1″ of the back of the mortised member and is made slightly dovetailed in form. The tenon is neatly fitted, two saw cuts are made, one at each side of the tenon, about $\frac{3}{16}$″ from the side. Into each of these a wedge is inserted; when the whole is ready, the tenon is glued and forced home. During this operation the wedges are urged into the saw cuts, causing the end of tenon to spread and fill the dovetailed mortice.

Bridle Joint is the name given to that joint, as shown in figures 514 and 515, that has its mortice or slot on the member that would be tenoned in the ordinary method, and the piece on which a sunk tenon is formed would in the usual joint be mortised. It is more expensive to make, but some prefer it to the mortice and tenon joint, as any bad workmanship can be easily detected.

Strut and Beam Joints.—Where struts are used to strengthen horizontal beams or shores, a straining piece is usually fixed to the beam, and the ends of the struts cut as shown in figure 516. Where the horizontal member is short, the straining piece is dispensed with and the ends of the struts are butted.

Joints for Struts and Ties.—These may be constructed as follows:—

(*a*). With oblique tenons which would be liable to shear, or assisted by plate bolted to tie, as shown in figure 517.

(*b*). By inserting a piece in grooves cut in rafter and tie beam, to prevent sliding, as in figure 518.

(*c*). With single abutment and tenon, as shown in figures 519 and 520. This is simple, effective, and generally used when there is sufficient length of tie behind strut to resist shearing stress.

(*d*). *Bridle Joints.*—This is a method employed to increase the shearing area; it is especially applicable to such work where the length of tie in front of strut to resist the thrust is small, as shown in figures 521 and 522. In addition to having a large shearing area, it has the advantage that any defect in the fitting would be apparent.

Fig. 517.

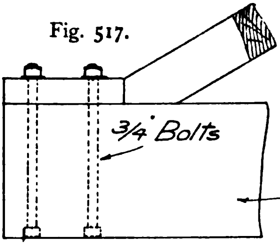


Fig. 518.

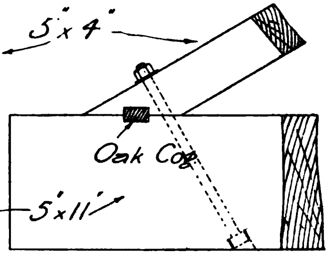


Fig. 519.

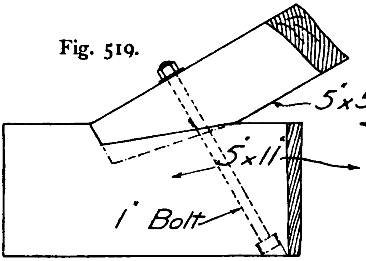


Fig. 521.

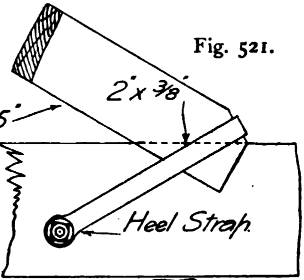


Fig. 520.

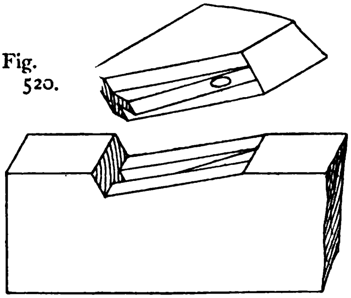
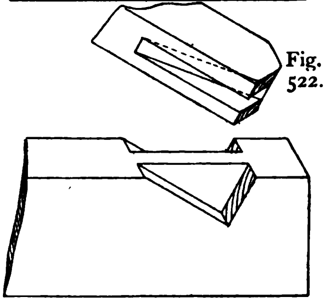


Fig. 522.



Fastenings.—Joints in carpentry should have white-lead applied with a brush over the surface forming the joint, and may be secured in their positions by the following fastenings:—

1. Pins { Wood Pins. Nails. Bolts.
2. Wedges.
3. Straps.
4. Sockets.

Pins.—These may be of wood or iron, and may be subdivided as dowel pins, trenails, spikes, dogs, screws, and bolts.

Dowel Pins.—When boards are required to be kept in the same plane surfaces, and yet not resist the shrinkage of the wood, dowels out of oak or hard wood of straight grain and split to the diameter required, and not cut with the saw, so that none of the fibres are cut across, and slightly tapering in their length, are employed as in the example of flooring, figure 556. Dowels are used to fix mortice and tenon joints, and are especially applicable for large or triangular framing to pull the shoulders tightly up, which method is called drawboring, which consists of boring through the mortised piece, then marking the tenoned member and boring it, not exactly in the mark, but towards the outside corner of shoulder, which has the effect, when the dowel is driven with great force, of bringing the shoulder up closely, as shown in figure 754.

Trenails.—Hard-wood pins of large diameter are called trenails, and are extensively used in shipbuilding or in positions where iron fastenings would be liable to rust. The force required to shear English oak across the grain is 4,000 lbs. per square inch.

Nails.—Nails are pieces of metal plate or wire, tapering or prismatic, usually pointed and headed, all of which are cast, cut, or stamped. They may be obtained in cast iron, wrought iron, steel, zinc, copper, brass, or in composition metal. Many have one pair of sides parallel in length. Such should always be driven with those sides parallel to the length grain to reduce the tendency of the nail to split the wood in its progress through the latter after each blow. Hard woods are bored to receive the nails; but in the softer woods this is seldom necessary. There is a great variety of nails; those in common use are manufactured from wrought iron or steel.

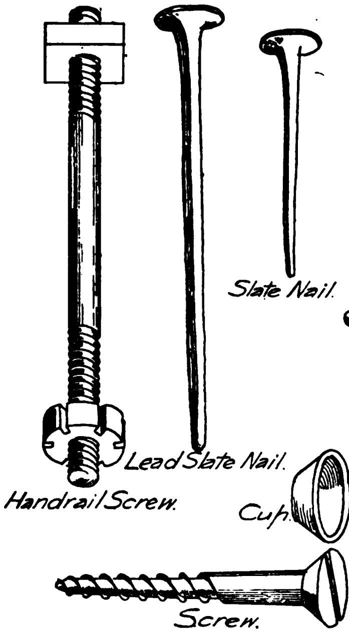
Cast-iron Nails.—These have been used for slating purposes, but are very brittle and are now discarded.

Wrought-iron and Steel Nails.—Cut clasps are cut by machinery from wrought-iron and steel plates, to the form shown in Fig. 523, and are the nails most commonly used. Clasp nails 4 inches and above in length are known as spikes. Nails cut from plates of wrought iron by manual labour, of the form shown in Fig. 523, are particularly known as wrought nails, and possess the property of bending sufficiently to clinch without breaking. Of late years, however, these have been produced by machinery, which has been improved to cut sufficiently and yet not to destroy the tenacity and pliability of good wrought iron.

Spikes are iron nails above 3 inches in length, extensively used in fixing timbers together. They require to be hammered in with great force. Spiking is a cheap method of fixing. The holding power is computed from experiments made by Captain Fraser, R.E., to be in fir from 460 to 730 lbs. per inch in length exclusive of thickness of cover plate.

Brads.—Tapering nails of parallel thickness with heads projecting only on one side, as shown in figure 523, are used to connect parts together where the nail hole is required to be of the minimum size.

Needle Points are small steel pins, circular in section, similar to the ordinary needle, but without eyes. These are used to fix hard wood moulding to joiners' work, and also in the process of veneering.



Figs. 529–533.

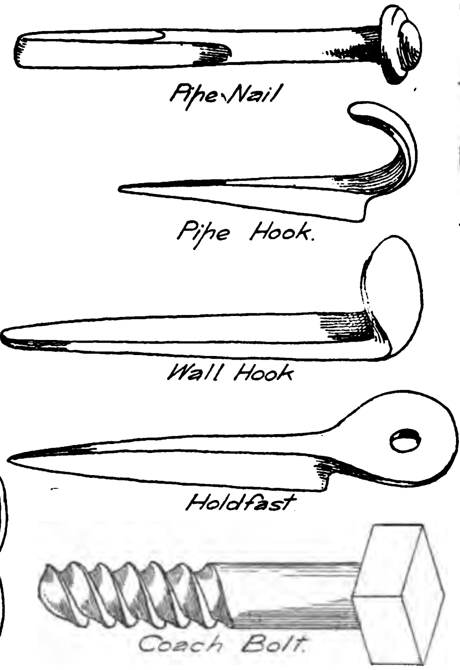


Fig. 524–528.

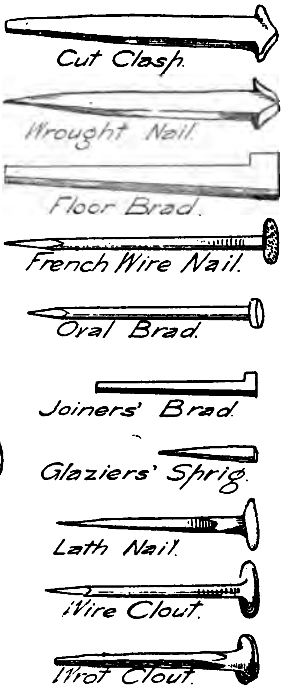


Fig. 523.

Figs. 523–533. Nails and Miscellaneous Fastenings.

Clout Nails.—These are nails with shanks rectangular or circular in section, with large, flat, circular heads, as shown in figure 523. Small clout-headed nails are called tacks.

Slating Nails.—Zinc, copper, and composition nails of this type are largely used to secure slating, as they resist oxidation better than the iron. Slates are frequently fixed with lead nails (as shown in figure 530) where slates are laid upon iron lathing.

Lath Nails.—A form of iron clout with a tapering shank, square in section, the sides of the shank being rough, as shown in figure 523.

Wire Nails.—These are usually circular, elliptical, or rectangular in section, and are usually known as French nails. They are very tough and strong, and do not break so readily as the clasp, but whilst being driven in position are apt to split the wood. Those circular in section, as shown in figure 523 are often used in packingcase making, and the elliptical, with small heads, for securing mouldings to joiners' work.

Glaziers' Sprigs.—These are small iron nails square in section, reduced at one end to a point and without heads, as shown in figure 523, used to fix glass before puttying.

Pipe Nails.—These are of wrought iron, circular shank, chisel pointed with circular heads, as shown in figure 524, used for securing stack pipes to brickwork.

Pipe Hooks.—These fastenings of wrought iron of the shape shown in figure 525, hooked at one end to secure pipes, and having a shoulder to permit of being driven with the hammer.

Wall Hooks.—These are of wrought iron of the form shown in figure 526, the head is turned at right angles to the shank. When used they are driven into the joints of the brickwork, and are employed for securing woodwork.

Holdfasts.—These have shanks similar to wall hooks, as shown in figure 527. The head is flattened out and a screw hole is drilled and a shouldered formed for the purpose of driving it. They are driven into the joints of brickwork, at the sides of timbers or framed woodwork, and the latter are secured by being screwed through the heads of the holdfasts.

Coach-bolts.—These are used for securing iron plates to timbers or timbers together. They have square heads to allow of turning by means of a spanner, and have wood screw threads, as shown in figure 528.

Screws.—These are used instead of nails where any vibration in fixing would be objectionable, or where pieces are required to be taken apart occasionally, as in figure 790. Figure 533 shows the form of screw used for fixing woodwork. They are usually made of wrought-iron or of brass, the latter resisting oxidation better than the former metal. They are made with one end tapering to a point to permit of the screw entering more easily, the thread being of a coarse pitch. The shape of the head generally determines the name, such as round-headed, countersunk-headed, etc. Where it is necessary occasionally to withdraw these, brass cups, as shown in figure 532, are employed next to the countersunk head to form a better finish.

Double-nutted Screws.—These fastenings, as shown in figure 529, are used in joinery work for securing heading joints. They have a thread at each end, a square nut at one end, and at the other end a circular nut slotted on edge. The pieces to be joined are bored to receive the screw; a mortice is made to receive the nut in each member at the requisite distance from the joint and intersecting the screw hole; the square nut is dropped into one of these mortices, the screw is inserted and threaded on same, the latter being square cannot rotate. The circular nut is now placed into the mortice of the other member and the screw inserted into the hole and threaded on circular nut, the latter being turned by a screw driver or a special punch till the joint is drawn very closely together.

The following formula from Hurst will give approximately the resistance of screws in wood:—

$f = d p l \times 42{,}000$ for soft wood, and by 83,000 for hard wood, d being the diameter of the screw, p the pitch or distance between the threads, l the length of the wood, all in inches, and f the resistance in lbs.

Bolts.—Wrought-iron bolts and coach screws are used where spikes or screws would not offer sufficient tensile resistance. The bolts are screwed at one end for a tapped nut to be fixed on, and to prevent nut and head sinking into timber when tightened up are supplied with wrought-iron washers, which against oak should be two and a half times diameter of bolt, and for fir three and a half times.

The ratios of the dimensions of the heads of hexagonal-headed bolts and nuts and square-headed bolts and nuts, in terms of the diameter of the shank, are given in the Chapter on Iron Roofs.

Dogs are pieces of flat or round wrought iron bent at ends, which are pointed and hammered in to secure timbers that butt against each other, especially used in shoring, rough stagings, and temporary structures. The holding power in lbs. is computed by Capt. Fraser, R.E., to be 600 to 900 lbs. for each inch in length of spike.

Wedges are pieces of wood cut taper to secure joints together, as in the mortice and tenon joint; when used in pairs, which draw up more equally, as for scarfs, are called folding wedges.

Keys.—The name given to hard-wood wedges, especially used to pull joints closely together, as in the tusk-tenon joint, figure 509.

Straps are fastenings formed of metal bands, usually wrought iron, to enclose timbers together and keep them in the required positions, and may have ends forged and screwed which pass through bearing-plates, to which they are secured, or may be drawn up by gibs and cotters, as illustrated in figures 468, 469, 614 and 615, or may simply form a stirrup or heel-strap, and be secured by a bolt, as in figure 531, where it is used to prevent the end of the tie-beam being sheared

The advantage of straps over bolts is that they need not cut into the timbers joined.

Tredgold's rules for straps are as follows :—

When longest unsupported part of the beam is

10 ft., the strap may be 1 in. wide by $\frac{3}{16}$ths in. thick.
15 „ „ „ 1½ „ „ ¼ „
20 „ „ „ 2 „ „ ¼ „

Considering the straps to fail when two sections are torn across, the total tensile resisting area in each example will be ·375 inch, ·75 inch, and 1 inch; and the tensile strength of wrought iron being taken as 20 tons per square inch, the ultimate resistances will then be 7½, 15 and 20 tons respectively.

Sockets are made of cast iron to enclose the ends of timbers, to prevent splitting, and to retain the pieces in the required position, as in figure 633. When used at the feet of members they are called shoes, as in figure 764.

CHAPTER VI.

FLOORS.

Definition.—The tiers or levels which divide a building into stages or stories are called floors. These may be of timber, or they may be constructed of fire-resisting materials; for the latter, *see* "Advanced Course."

Classification.—Floors for ordinary residential purposes are mostly made of timber, and may be divided under three heads—

Single-joisted Floors include bridging joists.

Double-joisted Floors include bridging joists supported by binders.

Framed Floors or *Triple-joisted Floors* include bridging joists supported by binders, the latter usually being framed into girders which finally support the load.

Single Floors.—When the total weight upon a floor is carried by a single system of joists, which span or bridge an opening, it is termed a single floor, and the joists are known as bridging joists; these are usually fixed 12 inches to 15 inches apart between the centres; although the simplest construction, with the same quantity of timber it forms the strongest floor. To these joists, laths may be nailed to receive the plaster, or ceiling joists are fixed, crossing the bridging joists at right angles, to which the lath and plaster is attached. There are two conditions governing the direction in which the joists are fixed: first, they are usually arranged to rest upon the walls which have the least span between; secondly, they are placed upon the walls which are weakened by the least number of openings, these are usually party walls.

Material.—In England, timber joists, binders and girders are usually of northern pine, often known as Scotch fir or yellow deal. It is to be preferred to white fir or spruce, as it resists greater transverse bearing stresses, is more durable, and the difference of cost is slight. For works where great strength is required, as in wood floors of large spans for public buildings, pitch pine is commonly used.

Loads upon Floors.—In ordinary practice it is usual to construct floors sufficiently strong to support safely the following loads:—

Ordinary dwelling houses, including weight of floor	1¼ cwts. per ft. super.
Public buildings, lecture rooms, etc.	1½ „ „
Warehouses, factories, etc.... ...	2½ to 4 „ „

All bridging joists to be strutted at intervals, not greater than 6 ft., and the minimum breadth of all binders and girders to be ·6 of the depth.

Calculation of Scantlings.—The ultimate resistance of timber scantlings may be calculated from the following formula known as the empirical, as stated below:—

$$W = \frac{k \times b \times d^2}{l} \text{ for concentrated load at centre of beam.}$$

$$W = \frac{2k \times b \times d^2}{l} \text{ for beams under distributed load.}$$

When l = length in feet.
„ b = breadth in inches.
„ d = depth in inches.
„ W = breaking weight in cwts.
„ k = breaking weight in wood beams 1 foot long, 1 inch broad, 1 inch deep, loaded in centre and supported at ends,

Value of *k*.

Material.	Central Breaking Weight in Cwts.
Spruce Fir	3½
Northern Pine	4
English Oak	4½
Canadian Oak	5
Pitch Pine...	5
Wrought-iron	18

Safe Working Load.—It is usual to allow a factor of safety of one-fifth the breaking weight.

Table giving the ultimate resistances of beams of northern pine, resting upon supports 1 foot apart, 1 inch broad, under transverse stress due to distributed loads. calculated by the formula

$$W = \frac{2k \times b \times d^2}{l},$$

also the safe working loads, $\frac{1}{5}$ being taken as the factor of safety for northern pine, English oak, pitch pine and wrought iron.

Dimensions.	Ultimate resistances in cwts. Northern pine.	Safe working loads in cwts. Northern pine	Safe working loads in cwts. on English oak.	Safe working loads in cwts. pitch pine.	Safe working loads in cwts. on wrought iron.
1 × 4	128·0	25·6	28·8	32·0	115·2
1 × 5	200·0	40·0	45·0	50·0	180·0
1 × 6	288·0	57·6	64·8	72·0	259·2
1 × 7	392·0	78·4	88·2	98·0	352·8
1 × 8	512·0	102·4	115·2	128·0	460·8
1 × 9	648·0	129·0	145·8	162·0	583·2
1 × 10	800·0	160·0	180·0	200·0	720·0
1 × 11	968·0	193·6	217.8	242·0	871·2
1 × 12	1152·0	230·4	259·2	288·0	1036·8
1 × 13	1352·0	270·4	304·2	338·0	1216·8
1 × 14	1568·0	313·6	352·8	392·0	1411·2
1 × 15	1800·0	360·0	405·0	450·0	1620·0
1 × 16	2048·0	409·6	460·8	512·0	1843·2
1 × 17	2312·0	462·4	520·2	578·0	2080·8
1 × 18	2592·0	518·4	583·2	648·0	2332·8
1 × 19	2888·0	577·6	649·8	722·0	2599·2
1 × 20	3200·0	640·0	720·0	800·0	2880·0

To determine the safe resistance of a given beam under transverse stress, under a distributed load, find the safe load of a beam 1 inch broad by the depth under consideration, multiply this by the breadth in inches, and divide by the length in feet of the given beam: the result is the strength of the beam.

Example: The following is an example showing the method of using the table:—

Let the double floor shown in figure 562 be taken. Determine the breadth of a beam of northern pine 7 inches deep to span an opening of 8 feet, and to have a safe resistance of 1½ cwts. per foot super. The distance from centre to centre of adjacent binders is 8 feet, and the bridging joists are fixed at 14 inches centre to centre. The load supported by each bridging joist will therefore equal the area multiplied by 1½ cwts. $=8\times 1\frac{1}{6}\times 1\frac{1}{2}=14$ cwts. Let 7 inches equal the depth, then from the table given:—
7″ × 1″ × 1′ 0″ between supports will carry safely 78·4 cwts. distributed load.
7″ × 1″ × 8′ 0″ ,, ,, 9·8 ,, ,,

$$\therefore b=\frac{14}{9{\cdot}8}=1{\cdot}43 \text{ inches nearly.}$$

But as it is not wise to have floor joists less than 2 inches in thickness, as they tend to split while nailing the floor boards, let 2″ × 7″ be selected.

Next determine the dimensions of binders of northern pine, 20 feet between walls, and spaced 8 feet centre to centre, to carry safely a distributed load of 1½ cwts. per foot super. The distributed load in cwts. carried by each binder will be therefore, $20\times 8\times 1\frac{1}{2}=240$ cwts. Let the depth be given at 15 inches, then from the table given:—

15″ × 1″ × 1′ 0″ between supports will carry safely 360 cwts. distributed load.
15″ × 1″ × 20′ 0″ ,, ,, 18 ,,

$\therefore b=\frac{240}{18}=13{\cdot}3$ inches, say 14 inches net breadth; to this add 2 inches to compensate for any loss of strength due to the cogging; this will therefore necessitate a binder 15″ × 16″.

This binder might be substituted by an iron flitch girder to reduce the scantling. Let a depth of 13 inches be taken, and the beam to be of pitch pine, then from the table given:—

13″ × 1″ × 1′ 0″ wrought-iron between supports will carry safely 1216·8 cwts. distributed load.

13″ × 1″ × 20′ 0″ wrought-iron between supports will carry safely 60·84 cwts. distributed load.

$\therefore$ 240 − 60·84 = 179·16 cwts.

13″ × 1″ × 1′ 0″ pitch pine between supports will carry safely 338 cwts. distributed load.

13″ × 1″ × 20′ 0″ pitch pine between supports will carry safely 16·9 cwts. distributed load.

$\therefore \frac{179\cdot16}{16.9} = 10\cdot6$ inches nearly, and to compensate for any loss of strength due to the cogging, say 12 inches; this will therefore necessitate a pitch pine binder 12 × 13 inches, and a 1 × 13 inches wrought-iron flitch.

Basement Floors.—To comply with the model bye-laws, the site enclosed by the external walls of a house is required to be covered with cement concrete at least 6 inches in depth, the object being to prevent the rising of ground gas, and also to sterilize the soil, thus preventing any vegetable growth, and between the concrete and the under-side of floor timbers a distance of at least 3 inches to allow of the timbers being ventilated. Under the basement floors of houses half-brick walls, as shown in figure 534, are built generally about 6 feet apart to carry sleeper plates, to which the joists are fixed. The nearer the sleeper walls are constructed, the less will be the scantlings of joists required.

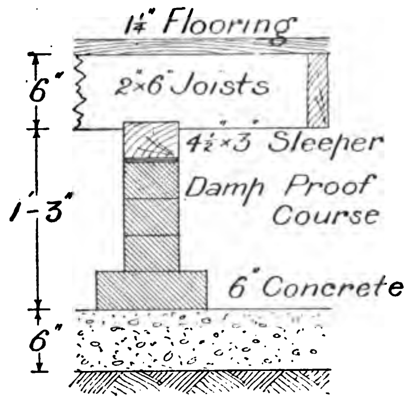


Fig. 534.

Upper Floors.—Floors above the basement are constructed with trimmed openings to form well holes for staircases, lifts, trapdoors and to clear flues. In order to satisfy the model

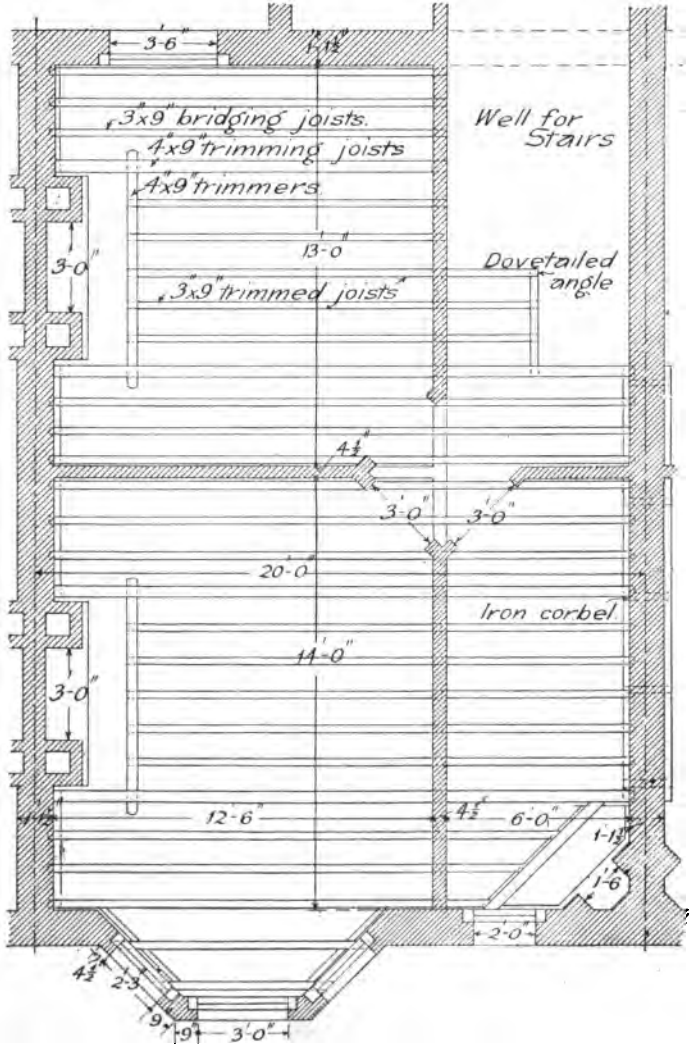


Fig. 535. Plan of Upper Floor, showing the trimming to clear flues in Chimney Breasts, &c.

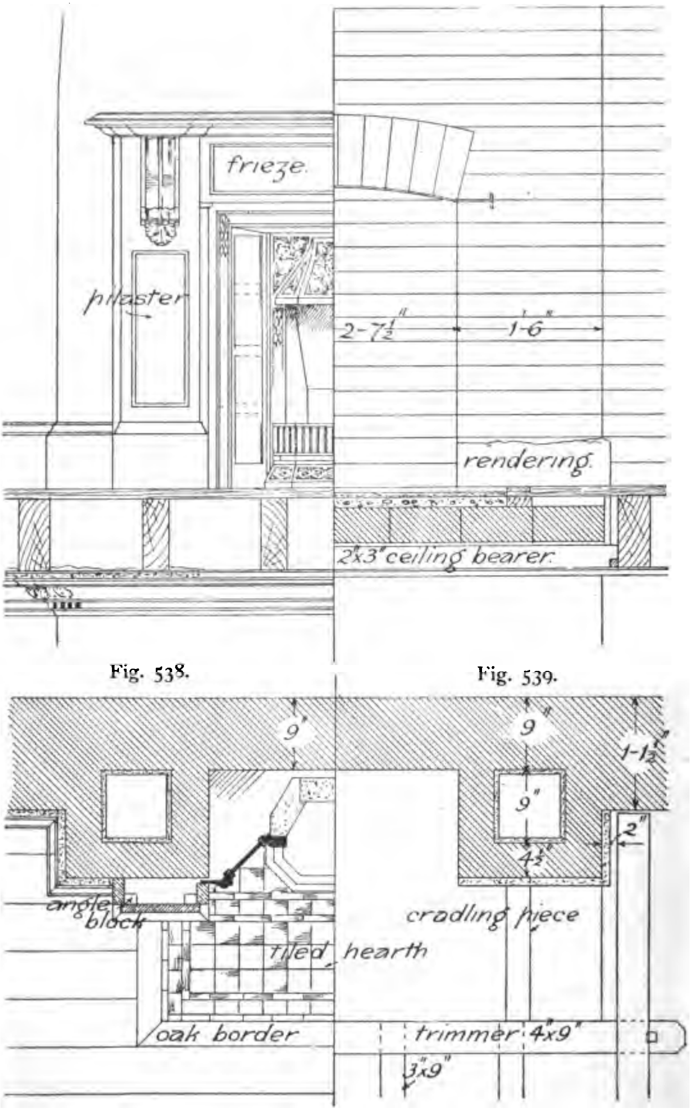


Fig. 536. Fig. 537. Fig. 538. Fig. 539.

Figs. 536—539. Example of Fireplace Construction.

Fig. 540.

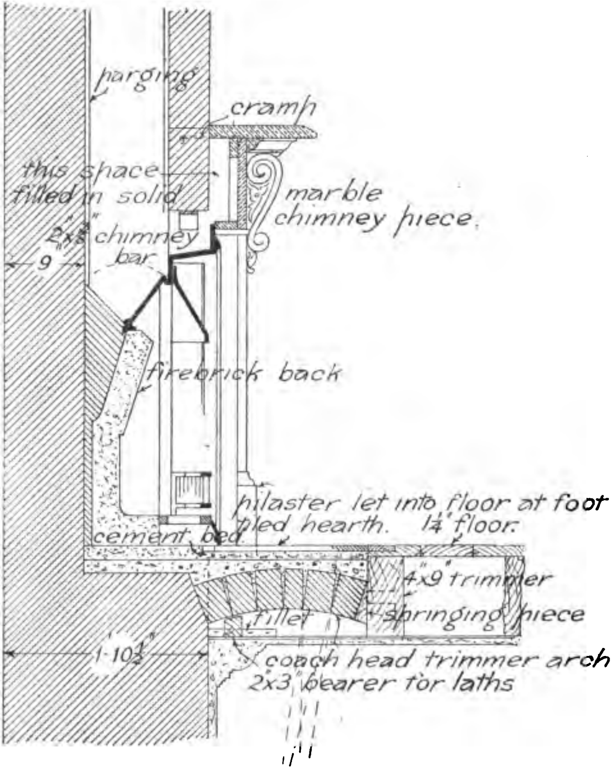
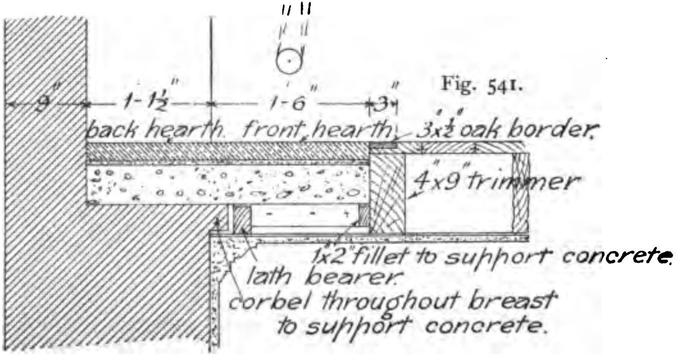


Fig. 541.



Figs. 540—541. Section through Fireplace.

bye-laws, which require that no wood-work may penetrate walls nearer than 9 inches from the flue, and no wall plate or joist may be within a distance of 2 inches from a flue wall less than 9 inches thick without it is rendered in cement.

Figure 535 shows the trimming to clear flues in chimney breasts, the joists being arranged in the shortest direction; this necessitates two trimming joists and one trimmer, which is carrying the ends of five trimmed joists. All the joints between, trimmed, trimmer, and trimming joists are tusk tenoned, as described in the chapter on joints in carpentry, to obtain the maximum bearing strength. To comply with the model bye-laws, 18 inches of fireproof material, 7 inches thick, must be provided in front of the fireplace, a coach-head trimmer arch is turned, as shown in figure 540, or a slab of concrete supported by a fillet nailed on the trimmer and resting on a corbel course on the breast, as shown in figure 541, which may extend from trimming joist to trimming joist, and never less than 9 inches on each breast. The coach-head trimmer arch is brought to a level surface by means of concrete, which forms a bedding for the hearth. Hearths are usually formed by slabs of stone, slabs of marble, tiles, or floated in cement. Where a stone is bedded it usually is 2 inches thick, and an extra ½ inch must be allowed for bedding. Marble hearths are usually 1 inch in thickness, and ½ inch allowed for bedding. White marble hearths and mantelpieces should be coated at back with a slip of plaster of paris, otherwise the lime mortar would cause dirty brown stains to appear on the front surface. Three-quarters of an inch must be allowed for the thickness of tiles and bedding, but for hearths finished by floating in cement, 1 inch is the thickness allowed. The floor is stiffened with herring-bone strutting, the rows of which should not be greater than 6 feet apart. Figure 542 shows an arrangement of herring-bone strutting.

Section through Fireplace.—Figure 540 gives section which

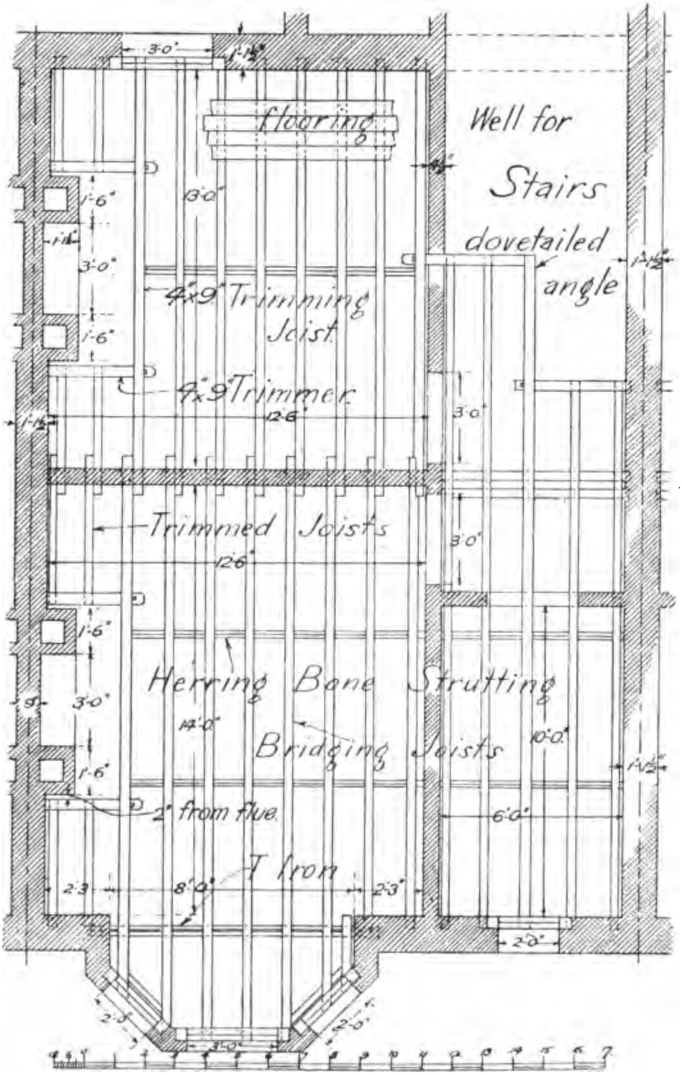


Fig. 542. Plan of Floor, with Herring-bone Strutting.

shows method of forming rough coach-head trimmer arch, with wood springing piece nailed to trimmer. The ceiling underneath is upheld by small joists resting on fillets 1½ inch by ¾ inch, nailed to trimming joists; or the ribs used as the temporary centre of the arch are allowed to remain to answer that purpose.

In wide chimney breasts the arch is sometimes stopped before it reaches the trimming joists, and a shaped piece of joist timber may be bedded on the back of the arch, provided it is 9 inches away from the opening to which the floor boards are secured. Sometimes a short joist is placed against end of arch, tusk tenoned into trimmer, the other end resting on an iron bar or corbel, which is fixed into the brickwork.

Figure 542 shows a trimming joist instead of trimmer forming the abutment of the arch.

Figure 542 gives the outline plan of floor with bridging joists arranged, parallel to the width of chimney opening, and extending from front to back. The bearing of joists over the opening for bay window is provided for by an inverted rolled steel tee, which permits of flat soffit below and the joists to be continuous. The external angle of joists in well hole for stairs is made as a dovetailed joint, as shown in figure 502. Where the distance from back to front is too great to permit of a continuous joist, advantage may be taken of the partition walls to use two joists lapping and spiked to each other as shown in figure 542.

Bearing of Joists.—The model bye-laws state that no timber must be built in party walls nearer than 4½″ to the centre plane of the wall.

There are various methods adopted for resting or fixing the ends of the joists upon walls.

1st. The joists are often built into walls, as shown in figure 542, and bear directly upon the brickwork, but this is objectionable, as the weight is not thoroughly distributed over the wall, and the ends of the timber are subjected to dry rot.

2nd. A better method is to build in a wrought iron bearing bar (2″ by ⅜″) upon which the joists rest, as shown in figure 543. This distributes the pressure, and is not open to the disadvantages of a wood plate. Pockets are sometimes formed in the brickwork allowing the timber at least ½ an inch clearance about the ends of joists, to allow for the circulation of air.

3rd. The joists may rest upon and be spiked to a wall plate which receives its bearing from a set-off or projection of the wall, as is usual at the lowest floor and at other heights of walls where the thickness is diminished by half a brick. This is a very good arrangement, as the wall plate then fulfils its function of distributing the pressure of the floor without reducing the section of the brickwork, as shown in figure 545.

4th. The method of corbelling is adopted for thin walls to take the bearing of joists. Continuous corbels are formed of two or more courses of bricks set off 1⅛″ each course as shown in figures 89 and 90, party walls are often diminished in thickness 4½″, a projection of 2¼″ is thus obtained on each side. This is insufficient to form the bearing for the joists, but may be made wide enough by corbelling out, 1st, by one corbel course of 2¼″ projection or by wrought iron corbels placed 3 feet apart as shown in figure 544. The best corbels to support the wall plate are of wrought iron (as shown in figure 544), and are made 4 inches wide and ½ or ¾ inch thick, bent at the ends as shown and built into the walls about 3 feet apart. They should be let in the wall 9 inches with sufficient weight above, which should always be noted, and care must be taken that they rest upon good hard bricks or stone to prevent crushing at the edge.

Bearing Joints of Joists upon Wall Plates.—Joists may simply rest upon the wall plates or binders, the lower surface

Fig. 543.

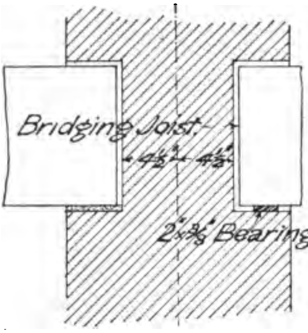
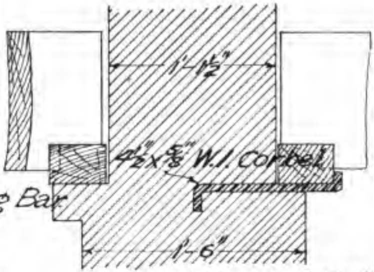


Fig. 544.



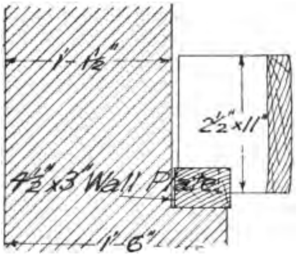


Fig. 545.

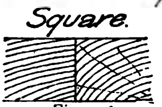


Fig. 546.

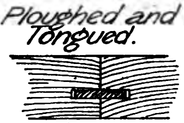


Fig. 547.

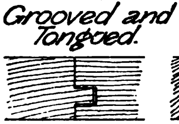


Fig. 548.

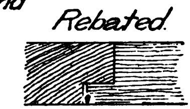


Fig. 549.

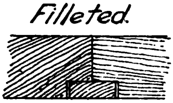
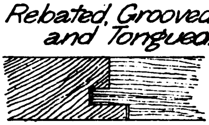


Fig. 550.



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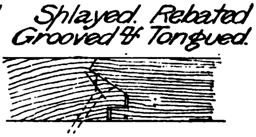
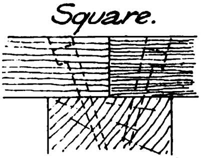


Fig. 552.



ig. 553.

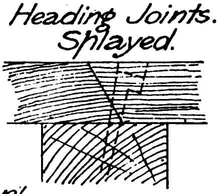


Fig. 554.

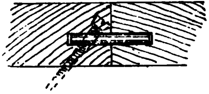


Fig. 556.

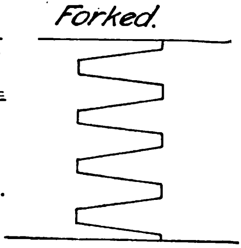


Fig. 555.

Figs. 543–556. Bearing of Joists, and Joints of Flooring.

of joist resting upon the upper surface of binder or plate, and fixed by being nailed; by this method the full depth of the joist is obtained, which is the chief aim, with the least labour.

They are often notched, but this is not good, as if there be a shake or defect in the timber below the notch it is liable to rupture by a load, which if the depth were not cut would be safely carried by the joist, as the effective depth of the joist is reduced by the depth of the notch. If, however, the plate be housed, as shown in figure 545, to take the bearing of the whole depth of the joist, loads tend to force together any shakes in the timber, and the full value of its depth is obtained.

The wall plate often has a fillet about 1″ by ¾″ nailed or worked on its upper surface, the joist being notched over; this is known as a cogged joint. The cog should always be placed on the inside edge of the wall plate so as to give the latter as great an area as possible to resist the detrusion or sliding of the projecting part.

Joints in Bridging Joists.—If it is necessary to make a joint in the length of a bridging joist, it should always be arranged to come over a binder or the head of a partition. If there be no ceiling underneath, they should be bevelled halved together, care being taken that each joist has a bearing for its whole depth in the notching, as shown in figure 565. If, however, the continuity of the centre line of the joists is of no great importance, the joists should be laid lapping side by side and spiked together, as shown in figure 542. This is a stronger method, giving much greater bearing, and the joists are easily nailed together.

Trimming.—This is the method of arranging timbers to carry the ends of those bridging joists which are cut short to form openings or well holes and to clear flues.

Those timbers which are cut short are termed trimmed joists, those which carry their ends and distribute the weight on the walls or other timbers are known as trimmers. The joists which carry the trimmers are called trimming joists, and these are generally parallel to the ordinary bridging joists, as shown in figure 535.

In practice trimmers are made of the same scantling as the trimming joists, the latter usually being one inch broader than the bridging joists.

Strutting.—Joists laid with boards on top, and lath and plaster underneath, are found to be insufficient to prevent lateral bending and vibration under pressure. To remedy this, which is injurious to the walls and to the timber members, strutting is placed in straight continuous rows at intervals of not more than 6 feet apart, which reduces to a great extent this defect and adds greatly to the stiffness and strength of a floor by distributing the pressure from any concentrated load.

The following are two methods of strutting :—

Herring-bone Strutting consists of pieces about 2 inches by 1½ inches, fixed as shown in figure 558. It is usual instead of boring for nails to make saw cuts at ends of struts, and through these channels to drive the nails. By doing this any danger of splitting is avoided. This method has the recommendation that it acts where its leverage to prevent bending is greatest, viz., at the edges of joists, and is used largely in dwelling-houses, although the labour in fixing is comparatively costly.

Solid Strutting.—One inch or 1¼ inch boards, nearly the same depth as the joists, are cut in tightly, and nailed between the joists, as in figure 557. This method is greatly used for dwelling houses, floors of factories and heavy buildings ; and if cut, so that its entire shoulder buts against the joists, is undoubtedly the firmer method; but without care is exercised the shoulders are apt to bite on the centre only. Sometimes long bolts of round bar iron are passed through all the joists in the centre of their depth, and the strutting crushed together by bolting. By this method no vibration is transmitted to the walls through the strutting. This undoubtedly is the idealistic and practical method.

Joints of Flooring.—The following are the general methods of arranging the longitudinal joints of flooring (which may be drawn together by means of special cramps, called dogs for fixing), and may be divided into two classes as follows:—

(*a*) Joints with visible fixing, as plain, ploughed and tongued, rebated, and rebated and filleted joints, as in figures 546 to 550.

(*b*) Joints with secret fixing, as dowel, rebated, grooved and tongued, and splayed, rebated, grooved and tongued, as shown in figures 556, 551, and 552, and these may be again sub-divided into joints which do and do not admit of dust passing through when the boards have shrunk.

Plain or Square Joint Laid Folding.—Square joints are forced together if iron cramps are not obtainable, in the following manner:—About six battens are taken and laid into position; one outside is fixed and the others are pushed together, and the boundary marked. The loose outside batten is now fixed ⅜ inch nearer to the board already fixed, and the others are placed with a plank across them, on which two or three men jump. This crushes the boards together, and closely fitting joints are obtained, and while kept in this position they are nailed to the joists.

Ploughed and Tongued.—A groove is made on each edge of the board lower than the centre, so as to obtain as much wear as possible, and a wood or iron tongue is inserted which prevents the edges curling up and any dust passing through, as shown in figure 547.

Grooved and Tongued.—Figure 548 shows this method of forming a dust-proof joint.

Fig. 557.

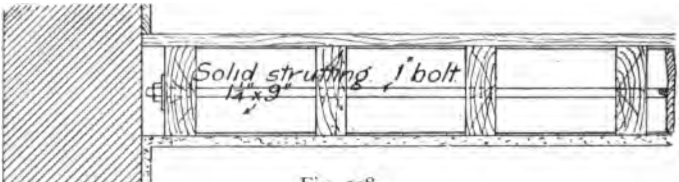


Fig. 558.

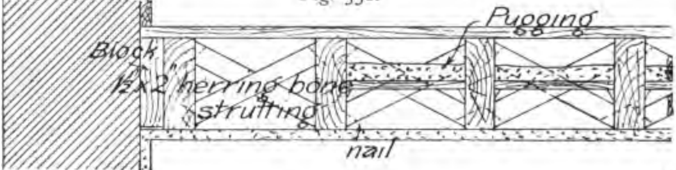


Fig. 559.

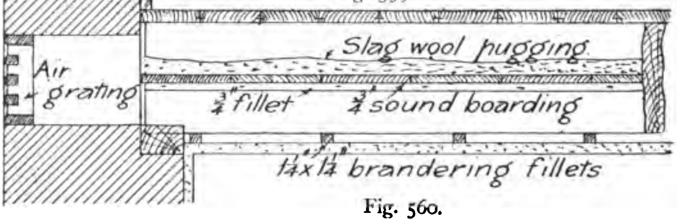


Fig. 560.

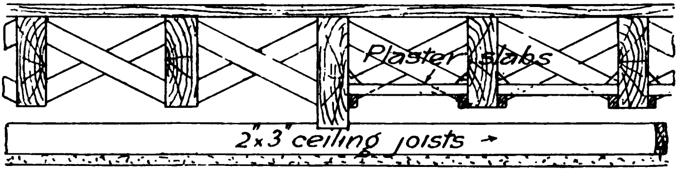
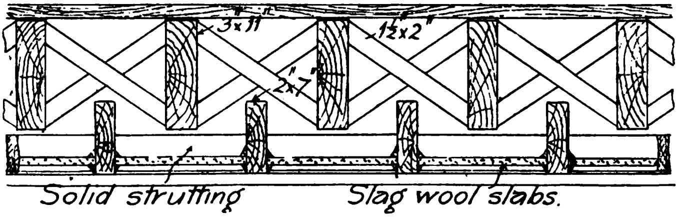


Fig. 561.



Figs. 557–561. Sound-Resisting Floors.

Rebated Joint.—For floors this joint, as shown in figure 549, has no special advantages to compensate for its extra expense, and is a construction not much used. It prevents dust passing through.

Rebated and Filleted.—The advantage of this method is that the greater part of the depth can be worn before the fillet is exposed, and is used in barracks and similar places where floors undergo heavy wear. Figure 550 shows this method.

Secret Joints.—Important or polished floors are often required to be secured in such a manner as not to show their fixing, nor unsightly nail holes, as would occur in ordinarily fixed flooring; they should be free to shrink or swell without splitting, which is accomplished by fixing on one edge only. Figure 556 shows an effective method, the boards being secured by dowel pins, and screwed to joists through one edge only. It was a method greatly used before the introduction of machinery, and should only be used upon a counterfloor.

Figures 551 and 552 show the methods by rebate, groove and tongue, secured by nails or screws on one edge only, and are dust proof. The expense of these joints is the great objection to their general use. The method shown in figure 552 is to be preferred, as the projecting portion for fixing is stronger than in the preceding.

Heading Joints.—The joints between the ends of floor-boards are called heading joints, and may be square, splayed, or forked.

Square Heading Joints.—These are usually secured by two nails on each side of joint, as in figure 553.

Splayed Heading.—When the ends of boards are bevelled only one board need be nailed, as in figure 554; the splayed heading will effectually secure the end of adjoining board. This is the method usually adopted.

Forked Headings.—These headings are made with a series of truncated triangular forks, which fit into each other, inclined to the length about 10°, as in figure 555. They are very expensive to make, and are only used in very good work.

Secret Headings.—These may be formed in a manner similar to the joint shown in cross section, figure 547.

Straight Joints.—This is the name given where the heading joints of adjoining boards are arranged on the same joist; such work looks unworkmanlike, as the plan of all heading joints should present a bonding appearance.

Prevention of Sound.—To prevent the passage of sound between the rooms of lower and upper floors, the following methods may be adopted:—

First.—By reducing the number of through timbers the continuity of transmission is interrupted which lessens the sound, every fourth or fifth joist being made deeper than the others. To these the ceiling joists are secured, as shown in figure 560.

Secondly.—The most effective consists of a double system of joists, each system being entirely separate, not connected in any part. With this system no sound can be carried by conduction through the floor timbers, and if all the members are bedded on felt, and the bridging joists strutted, as shown in figure 561, the passage of sound will be reduced to a minimum.

Thirdly.—Layers of list or felt are placed under every bearing of girders, binders, bridging joists, and floor boards to reduce vibration and sound.

Fourthly.—Various methods of pugging are used to prevent the passage of sound, the object being to deaden the sound waves. They are never quite successful in preventing the passage of sound, and are objectionable as they induce dry rot in the timber, and the circulation of air is often impeded, if not entirely stopped, if the pugging is not near the top or bottom of the joists. The pugging employed may consist of coarse plaster, slabs of coke breeze concrete, layers of slag wool, or slabs of fibrous plaster.

The fibrous plaster slabs are sometimes placed flush with the tops of the joists, the entire floor space being covered with felt immediately beneath the boarding in order to deaden the sound. This is effective in reducing the sound, but does not protect the lower portion of the joists from fire. The better plan is to place the plaster slabs as close to the ceiling as possible, as shown in figure 561, and have the tops of the joists only covered with felt. The flames would have a much smaller space to play upon, and the floor could be strutted and ventilated in the usual way.

Ceiling Joists.—These are the small joists that carry the lath and plaster ceiling only, and are suspended to other timbers. The usual dimensions are 2 inches × 3 to 5 inches, as smaller pieces might be split by the nails. They are fixed about 12 inches apart, and may be secured to the upper timbers by simply spiking, chase mortising or notching over fillets planted on sides to receive them, as in figures 560 and 573.

If ½-inch is multiplied by the number of feet spanned by the ceiling joists, it will give the necessary depth, when the thickness is 2 inches.

Lathing.—Laths are fixed about ⅜ inch apart, to the under side of joists, the opening and space in rear allowing the plaster to pass through and protrude, thus affording a key for the plaster, which key should not be interrupted at any part for more than 2 inches continuously. Joists above 2 inches in thickness should be counterlathed, which consists in nailing one or more rows of laths on the under side of thick joists. Laths should be fitted with a butted and not a lapped joint, and the heading joints should be broken every 18 inches.

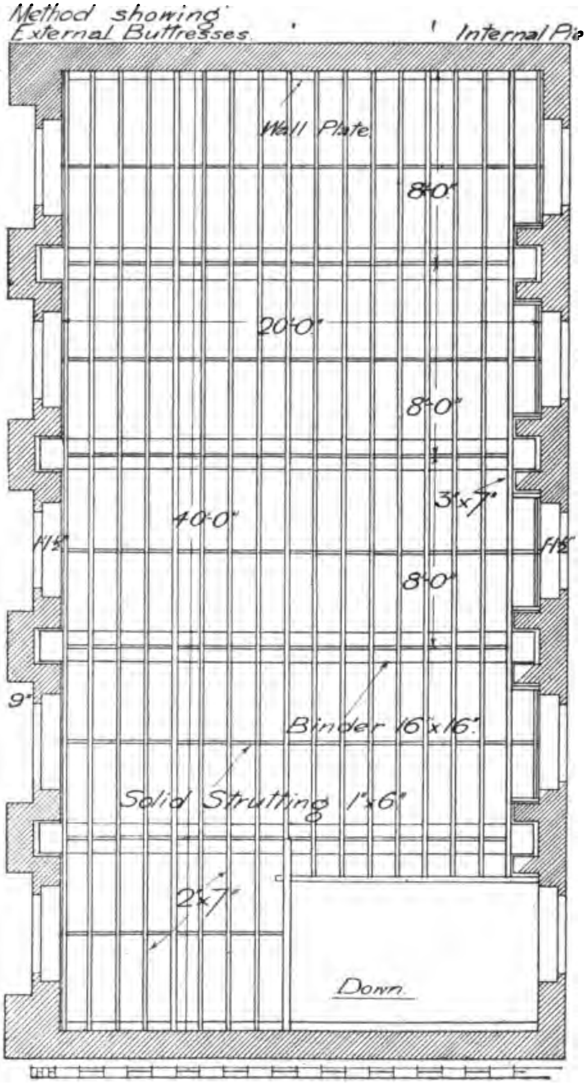


Fig. 562. Plan of Double Floor.

Brandering.—Fillets 1″ × 1″ are sometimes nailed at right angles to the under side of joists to receive the lathing, as shown in figure 559, to prevent the plaster ceiling cracking, through any slackness or slight movement of any separate joist, and also to allow of more complete circulation of air about the joists. These fillets are fixed at the most economical distances for the laths. This method is called brandering, the fillets being practically small ceiling joists.

Fig. 563.

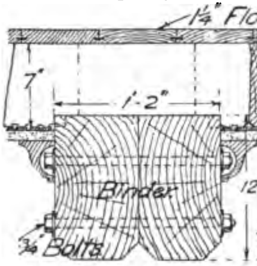


Fig. 564.

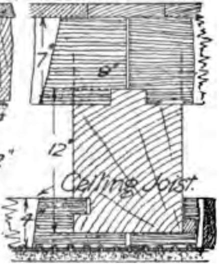
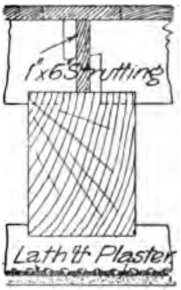


Fig. 565.



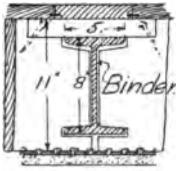


Fig. 566.

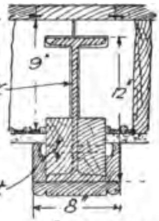


Fig. 567.

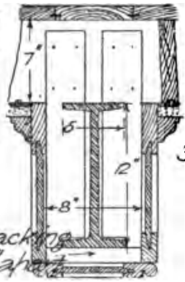


Fig. 568.

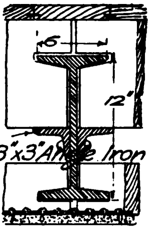


Fig. 569.

Double Floors.—These floors consist of bridging joists and binders, with or without ceiling joists, and are used where the supporting walls are perforated with openings. Columns, piers, or the uninterrupted parts of walls are arranged to support the binders. The binders stiffen the floors, and if ceiling joists fixed to the binders are used the passage of sound is minimised as explained on page 178.

Figure 562 gives the plan of a double floor, calculated to support safely a load of 1½ cwts. per foot super, the binders rest on stone templates built into walls. Ceiling joists, if any, are usually fixed exactly under the bridging joists.

Scantling for binding joists of wood may be calculated from the table given on page 162, as shown in the example worked on page 163. They are generally placed distances from centre to centre, not exceeding 10 feet.

Double Floor Sections.—Figures 563 to 569 show ordinary methods of arranging binders to carry floor and ceiling joists. Where the extra height obtained is considered a greater advantage than efficiency of sound resistance, the lath and plaster ceiling may be attached to the bridging joists, as in figure 566. The binder may be worked as illustrated in figure 563, which gives the ceiling a panelled appearance. If the projection of the binder in lower room is an objection, the bridging joists are often housed a great portion of their depth and notched over the binders, as in figures 564 and 565.

Wrought Iron and Steel Binders.—Rolled iron and steel joists are now extensively used as binders, the upper flange of which may support the floor joists, and the lower flange the ceiling joists, as in figure 569.

If the depth of the floor is required to be as shallow as possible, such joists for binders are useful, as the floor may be constructed without increasing the depth required by the bridging joists, as shown in figure 566.

Figures 567 and 568 show two methods of rolled iron or steel joists used as binders, to give the ceiling a panelled appearance.

The methods of calculating the necessary sections for wrought-iron and steel joists are given in my "Advanced Course."

Framed Floors, or triple-joisted floors, are composed of

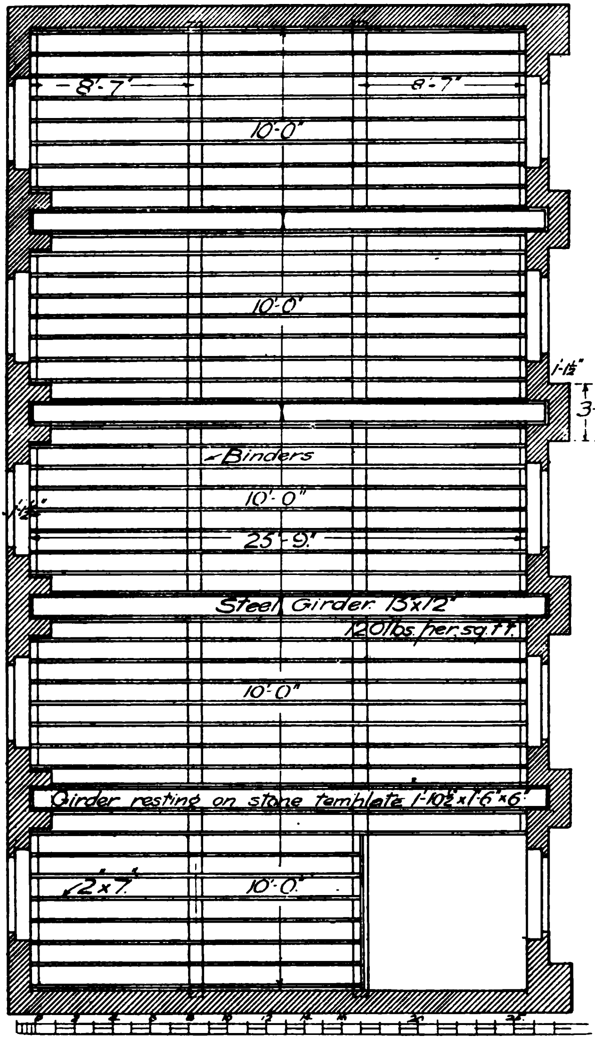


Fig. 570. Plan of Framed or Triple-joisted Floor.

Fig. 571.

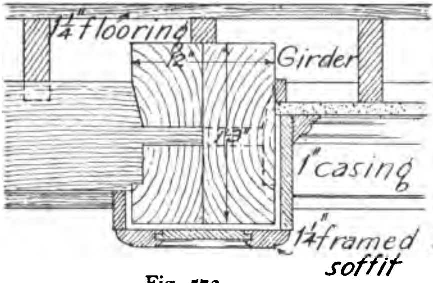


Fig. 572.

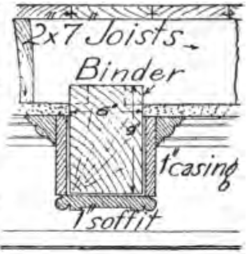


Fig. 573.

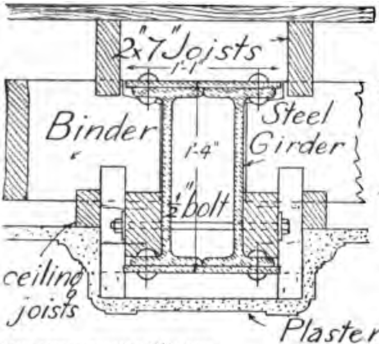
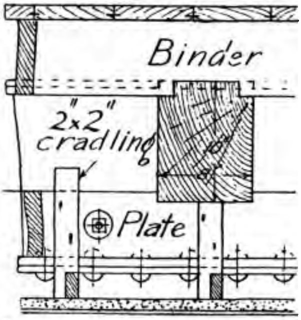


Fig. 574.



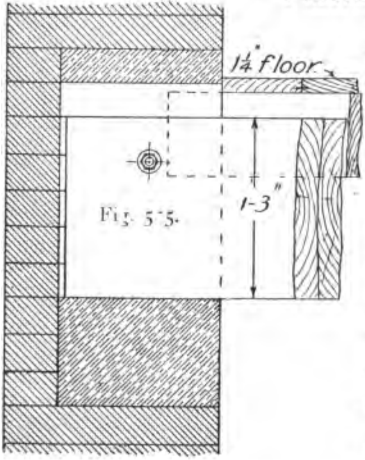


Fig. 575.

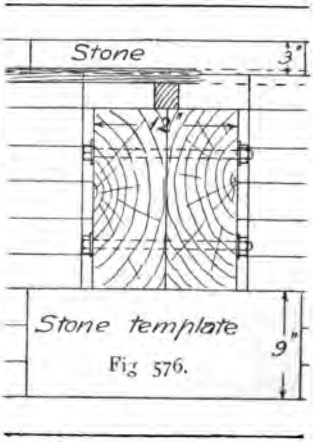


Fig. 576.

Figs. 571–576, Framed Floor Details.

bridging joists, binders and girders, with or without ceiling joists, and are used in large factories, warehouses, and public buildings, where the span to be covered is great, or the number of supports comparatively few, and have all the advantages of a double floor, but to a greater extent.

Fig. 577.

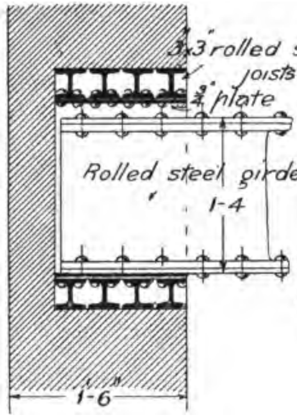
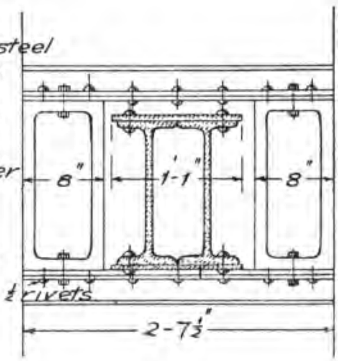


Fig. 578.



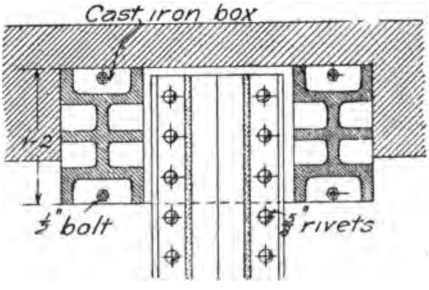


Fig. 579.

It is not usual to place wood girders from centre to centre, greater distances than 10 feet apart.

Figure 570 shows a framed floor, calculated to support a load of 1½ cwt. per foot super.

Figures 571 to 574 give methods of applying wood, rolled iron or steel joists as girders.

The binders in figures 571 and 572 are fixed by tusk tenoning and spiking into the girder.

Pockets in Walls.—All timbers penetrating walls should rest on stone templates, with a clear space of ½ inch at least, to allow of a free circulation of air around the ends of timbers, and, to prevent dry rot being induced, the ends of the timbers being in no case allowed to touch the brickwork. Small cavities may be bridged at the top with stone lintels, as shown in figures 575 and 576, or the larger ones with a rough relieving arch.

Where the girders are supported by projecting piers care should be taken that the rebatement is not so large as to reduce the sectional dimensions of the pier to an unsafe area. If this cannot be avoided a template formed by small steel joists is bedded, and two cast-iron blocks are bolted to it to form the sides of the rebatement, and upon these a series of small rolled steel joists are placed and bolted, as shown in figures 577 to 579.

Ventilation of Floors.—All timbers of floors, especially those near the ground, should be well ventilated to prevent destruction by dry rot. The proper necessary ventilation may be obtained by the insertion of iron or terra-cotta air bricks at intervals in the outer walls between ceiling and floor board levels, as shown in figure 559, and by boring a number of horizontal holes through the joists at the centre of their depth, or by brandering, so that the air may circulate through all.

The ventilation is more complete when, instead of a few iron air bricks, a course of perforated bricks is inserted at two or more sides of the floor.

CHAPTER VII.

PARTITIONS.

Definition.—Partitions are screens used to divide flats into rooms, in addition to which they also often act as deep trusses to support floors.

Partitions may be built of brick, plaster slabs, coke breeze concrete, or of wood, and also of various combinations of these materials.

Classification.—Timber partitions may be divided into three classes, viz.:—

(*a*) Common.
(*b*) Supported at ends and carrying own weight only.
(*c*) Supported at ends and carrying floors, roofs, etc.

Characteristics.—The advantages of timber partitions are first, lightness, an important consideration when the partition cannot have a solid bearing along its whole length, and can only be supported by a wall at either end. Secondly, rigidity, which is obtained by the triangulation of the framing; this also gives the walls a substantial support and aid in resisting external pressures. Thirdly, the facility of construction in any position, and the convenience with which loads may be transmitted and concentrated in any part or parts of the walls.

Timber partitions lack the fire-resisting properties of brick or concrete walls, they do not prevent the passage of sound to any great extent, and should not be erected in basements or floors next to the ground unless they are thoroughly protected from damp; brick or stone walls being preferable in this position.

Brick.—Brick walls from half brick and upwards in thickness are often used for partitions which are built in the usual manner.

Coke Breeze.—Partitions are now largely built of coke-breeze concrete; 4 parts of breeze to 1 of Portland cement. Such material when used for partitions is usually supplemented by light iron tie rods, placed horizontally when fixed into the walls, and vertically when secured to light bar iron heads and sills. The concrete is poured into frames erected to receive it, in layers of about 1′ 6″ in height, until the whole is finished.

These partitions are light, fire-resisting and strong, the usual thickness of same being about 4½ inches.

Hollow Brick Partitions.—Hollow bricks 12″ × 2½″ × 6″ with joggled joints, as shown in figure 580. With a smooth egg glazed surface, or with dovetailed sinkings formed to receive the plaster, are made by Messrs. Picking & Co., London, N., and have been extensively used. They are fire-resisting, sound resisting, strong and light compared with bricks, and are only about half the thickness of brick partitions.

The weight of 100 square feet of this partition is 1,232 lbs. exclusive of plaster.

Mack Plaster Slabs.—Plaster slabs with reeds embedded with a joggled joint and set in plaster, as shown in figure 581, are now used for partitions and ceilings, and are known as the "Mack" partition.

Extreme lightness renders it possible to construct them in large slabs, this results in great economy in construction owing to the fewness of the joints and the rapidity with which partitions can be erected. They are made in thicknesses of ⅜ inch, ⅘ inch, 1 inch, 1¼ inch for ceilings, and 2 inches, 2¾ inches, 4 inches for partitions, in slabs from 26″ × 20″ to

6′ × 1′. They have been largely used in Germany, America, France, Scotland and England. They are fire-resisting, sound resisting, light, and for alterations can be easily cut with a saw.

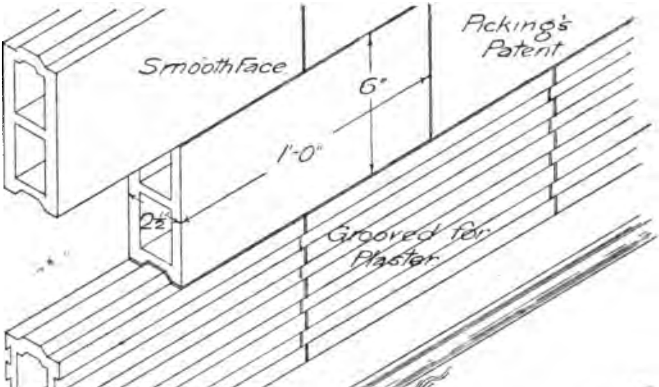


Fig. 580.

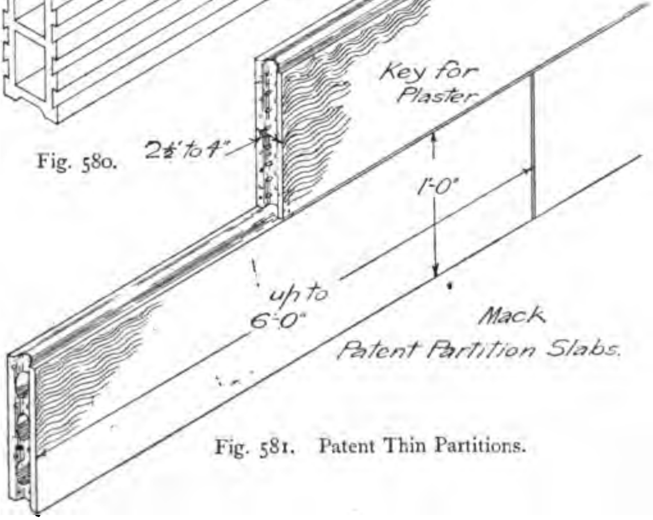


Fig. 581. Patent Thin Partitions.

They work out cheaper than the ordinary lath and plaster partitions. Special slabs with asphalte backing may be obtained

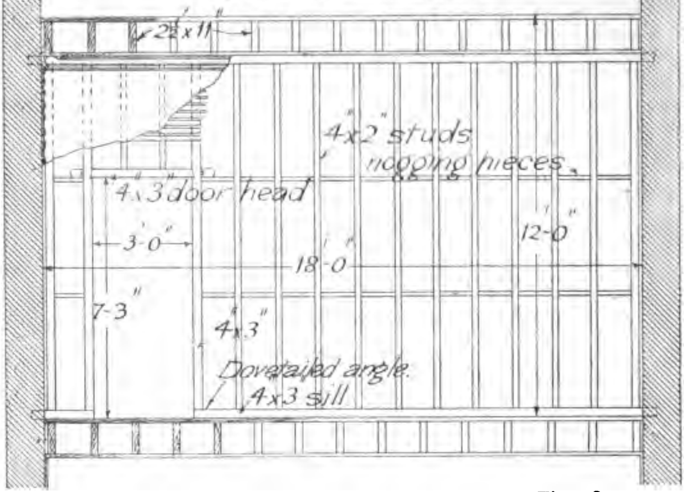


Fig. 582. Common Partition.

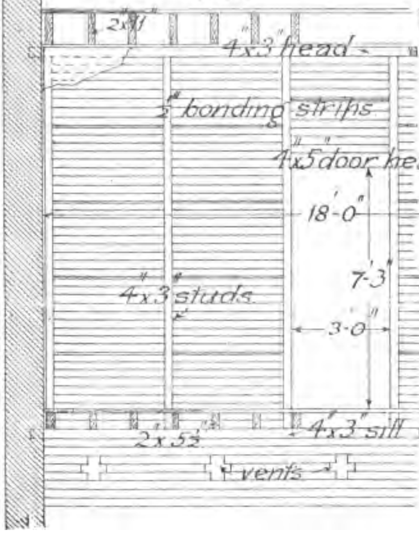


Fig. 583.

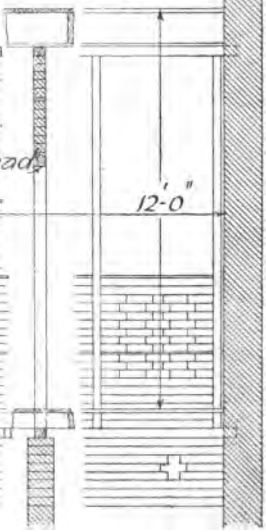


Fig. 584.

Figs. 582-584. Bricknogged Partition.

to form damp-proof courses. The weight of 100 square feet of these partitions 2¾ inches thick is 890 lbs.

Common Partitions.—Partitions designed to divide flats into rooms, where the floor is strong enough to support them, there being consequently no need to truss the same, are termed common partitions. They consist of a sill and a head with a number of uprights called studs tenoned to them, the whole fitting tightly between the floors below and above, as shown in figure 582.

Care should be taken when placing the sill in position that it lies either at right angles to the floor joists below, or directly over one of the joists if it be parallel to them, so that a solid and uniform support may be obtained along its entire length. Care must be taken that common partitions are not placed on the floor boards between the joists, as in the event of the floor being taken up to be relaid, the partition would fail.

The studs, which consist of 4″ × 2″ quarters, placed 1′ 0″ to 1′ 3″ from centre to centre, are stump tenoned into the head and sill, and are stiffened in the direction of their length, by nogging pieces out of 4″ × 2″, cut tightly between the studs and nailed, or else out of strips 2″ × ¾″ let into the face of the studs and nailed, thus binding the whole together. The door studs, head and sill are formed of 4″ × 3″ or 4″ × 4″.

Bricknogged Partitions.—These are used for the prevention of fire and the passage of sound, and are a form of common partition, the spaces between the studs being filled in with brickwork 4½″ thick; the studs are made from 4″ × 3″ quarters, placed a distance of some multiple of a brick apart, usually either 2′ 3″ or 3′ 0″, and about every 2′ 0″ in height a wood bonding strip out of 4″ × ⅜″ should be placed horizontally between the studs and nailed to them, as shown in figures 583 and 584. Bricknogged partitions must always have a solid support along their entire length, otherwise they are liable to settle and crack the plaster and cornice. Half-brick partition walls should always be built in cement mortar.

If the partition does not exceed 10′ 0″ in height, it might with advantage be made entirely of brick, half-brick in thickness built in cement. Partitions above 10 feet in height supporting floors should have wood studs and bonding strips introduced to avoid any injury from vibration or shocks.

Coke-breeze concrete is often used as a filling instead of brickwork, the studs having a number of nails driven in their sides, so that they project about 1½ inch to form a key for the concrete, or better still the edges of the studs should be chiselled or sawn off at an angle of about 30° with the face of the partition. This forms a good key to retain concrete in position and does not interrupt the key for the plaster.

Trussing—The object of trussing is to obtain a rigid unalterable frame, designed so as to throw all the weight-carrying members into direct tension or compression, and to fail only when the members are stressed to their ultimate resistance. This is attained by triangulating the rectangular bays formed by the horizontal and vertical members by the addition of braces.

Distortion is prevented by arranging the loads to come over the apices of the triangles, when the stresses will be taken from all parts of the truss and transmitted to the supports.

All materials are inefficient to satisfy the theoretical requirements, owing to the expansion and contraction due to the variations in temperature. Timber is found to alter less in length than any other known building material, and is therefore well adapted for trussed frames, provided means are taken to prevent the shrinkage in width affecting its length.

Care should be taken in designing the partition that the sill is supported at equal distances along its length as far as the door openings will allow; this is done by upright posts tenoned into and connected to it by iron straps or bolts;

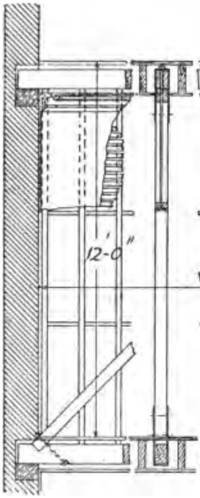


Fig. 585.

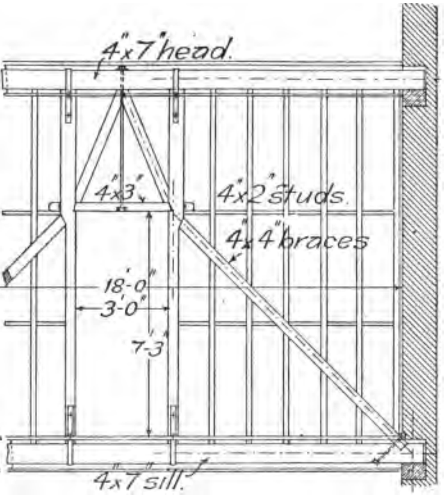


Fig. 586.

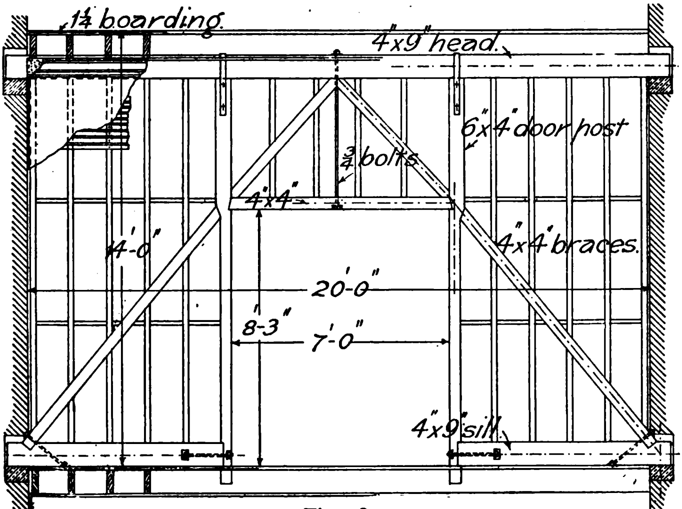


Fig. 587.

Figs. 585–587. Partitions supporting their own Weight.

the posts are supported at their upper ends by inclined braces, framed into them at that part, the feet of the braces being bridled into the sill at a short distance from the ends; the weight of the partition thrown on the sill is thus taken up the post and down the braces and transmitted directly on to the walls.

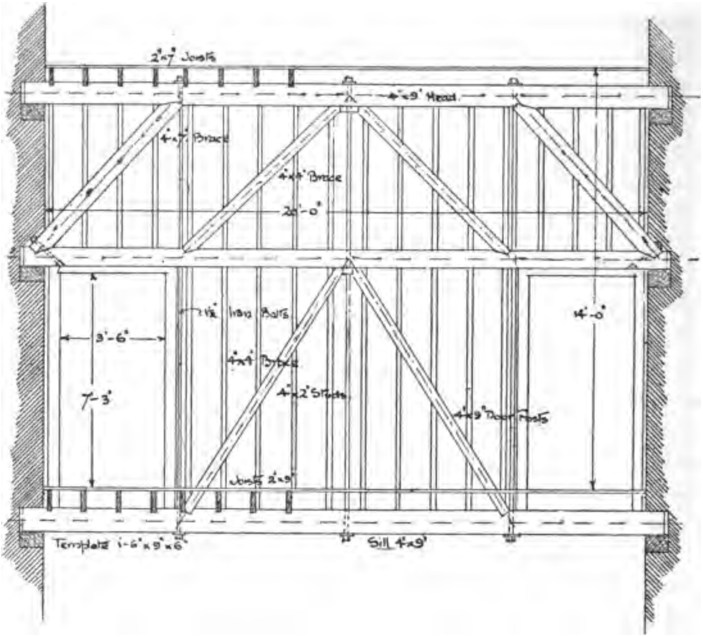


Fig. 588. Partition with Iron Bolts.

The tensional members in timber structures are always a source of weakness, owing to the difficulty of making the joints sufficiently strong, therefore such works are always supplemented by iron straps or bolts. Timber is often superseded by long iron bolts with heads and screwed nuts for the members in tension, as shown in figure 588.

Partitions supporting their own Weight.—These are employed when the floors are not strong enough to support the extra weight of a partition, and are therefore trussed so as to concentrate the weight of the partition on the two supporting walls, as shown in figures 585 to 587. It is better that the partitions should take their bearing on walls or supports at either end and not rest on any intermediate support, such as a cross wall, at any point in its span, as the unequal settlement of the supports may cause unsightly fractures in the plaster over the whole face of the partition.

There are two cases of this form of partition—1st, where the sill is parallel to the bridging joists in which the sill is placed between two joists, and can therefore be continuous from wall to wall, as shown in figures 585 and 586. 2ndly, that in which the sill is at right angles to the direction of the joists; if in this case it is not permissible to place the sill beneath the joist it must be placed above in two pieces. Figure 587 shows the method of framing to meet this condition.

Partitions supporting Floors.—Figures 588 and 590 show partitions supporting floors, the principal difference between these and the preceding being that all the members have to be made proportionately stronger to carry the increased weight.

If the rooms be at all high another horizontal member is introduced, called an intertie, the duty of which is to distribute the pressure on the walls, and also to avoid the necessity of long braces.

The intertie is usually placed directly over the door heads, thus dividing the partition into two horizontal bays, which are trussed as before described.

In new buildings the plastering should be left for the framing to shrink, until the walls have had time to settle, especially if the latter be of unequal heights, and so allow the partition to adjust itself, otherwise the plaster will be cracked.

Studs.—The studs, or vertical members, are stump tenoned into the sill head and intertie, similarly to door stud shown in

Fig. 589.

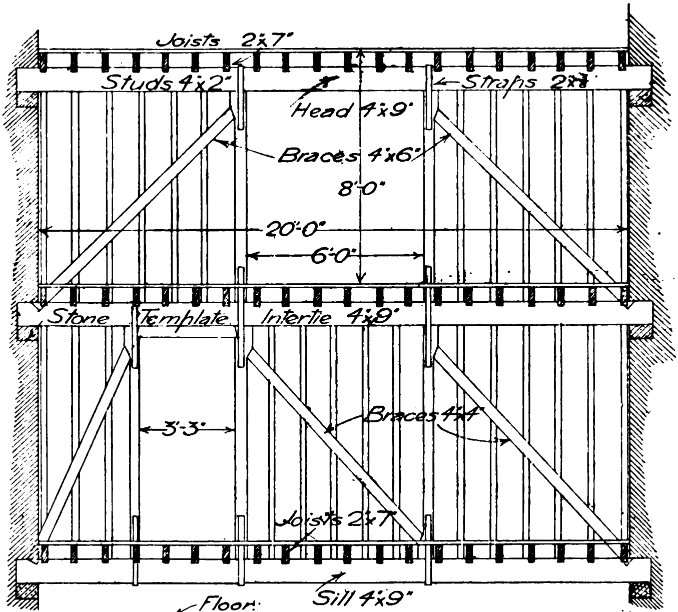
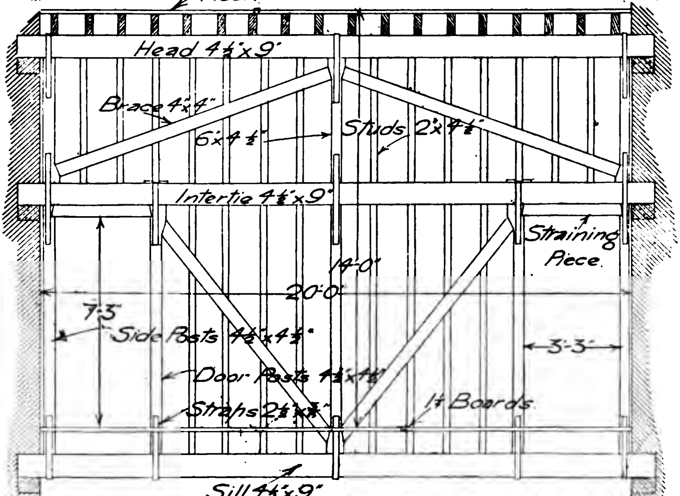


Fig. 590.



Figs. 589, 590. Partitions supporting Floors.

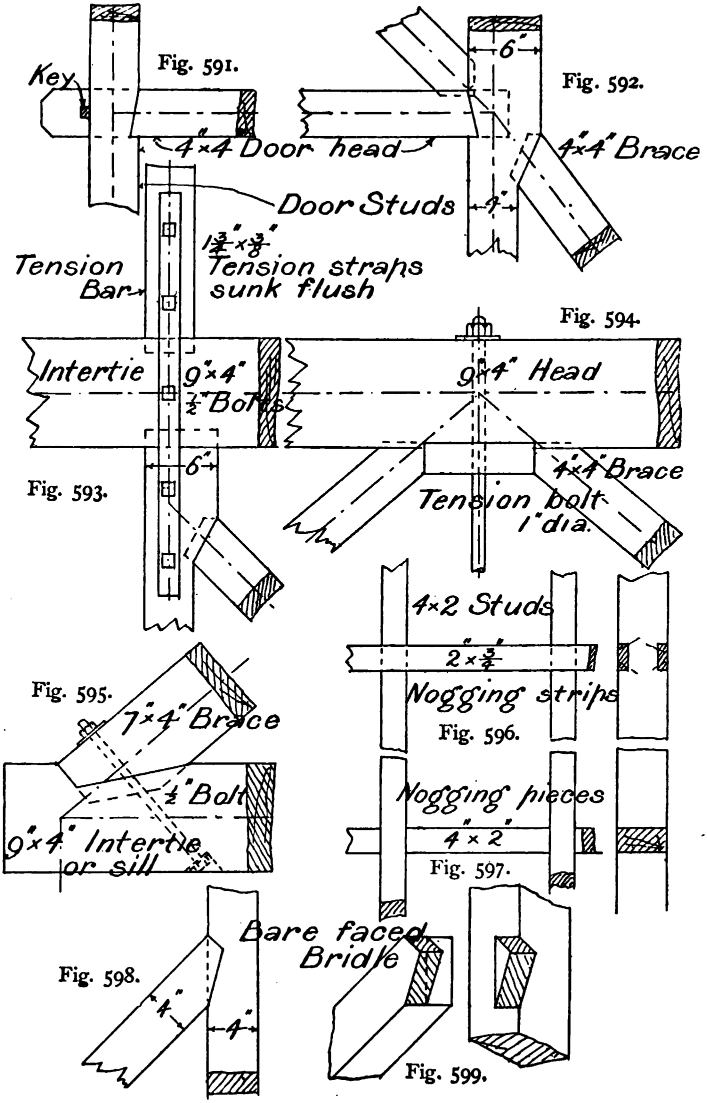
figure 593, but where they intersect a brace they are simply cut to the bevel and nailed on, not tenoned into it, which would weaken the brace. The special duty of the studs is to form a fixing for the lathing, to interfere with the key of the plaster as little as possible; their thickness, therefore, should not exceed 2 inches. To resist the vibration and shocks caused by the slamming of the doors, the door studs should be stouter, generally 4" by 4"; the angles are sometimes taken off these members to reduce the width on face with the object of preserving the plaster key, but a better method, on all wide members, is to counterlath, which consists in nailing laths at right angles to the covering lathing to all the main members of the partition of greater width than 2 inches.

Sills.—The sills in common partitions usually consist of 4" by 3" or 4" by 4" quarters, their special use being to receive the ends of the studs and to distribute the pressure evenly over the supports.

The sills in self-supporting partitions and those supporting floors vary in their depth, according to the weight to be carried. The sills receive the weight of the ordinary studs, which causes the former to be under a cross stress, and are supported at their two ends by walls, and at intervals by being hung to the uprights by iron straps or bolts; they also receive at both extremities the thrust of the braces, causing them to be under a tensional stress.

Intertie.—The intertie, as shown in figures 589 and 590, acts in a manner similar to that of a sill, its chief duties being to receive the inclined thrust of the braces and divert the pressure into a vertical direction, and also to distribute the weight of the partition over the wall.

Heads.—The head serves as a fixing for the studs; as a support for the joists above, as shown in figures 588 to 590; and as a straining beam to resist the thrust of the braces at their upper ends. It should always be connected at its



Figs. 591–599. Details of Joints and Connections of Partitions.

extremities to the lower horizontal members by bolts or tensional bars.

Braces.—The duty of the braces, or inclined members, is to give rigidity, and to transmit the weight on to the walls, and care should be taken that these are always arranged so as to be in compression.

When wooden upright members are employed, the ends of the braces are usually framed into the upright, with the exception of the lower ends when they occur at the extremities of the sill or intertie, at which part they should be framed into those members by a bridle or an abutment joint, as shown in figures 585 and 595, but where iron bolts are used as tensional members, the joint at both head and sill should be a bridle, as in figure 588, except where the extremities of two struts meet, and then they should be mitred and butted against each other and the horizontal member, and stump tenoned into the latter, as at the head shown in figure 588.

Joint for Door Head.—Figure 591 shows a housed and tenoned joint for door head. The housing is to obtain bearing strength, and the tenon is keyed to draw the shoulders up tightly.

Fixing of Partitions.—The sill, head and intertie should take their bearing on stone templates. If the partitions are arranged to act as cross walls they should be fixed, but if only to support themselves the ends of the timbers should rest in pockets so as to be thoroughly ventilated at all points.

The following are the scantlings of the timbers generally used :—

For common partitions, heads and sills = 4″ × 3″
Door posts and head ... ... = 4″ × 4″ and 4″ × 3″
Studs ... ... = 4″ × 2″

Double and Framed Partitions.—The scantlings of the principal members vary with the span, but are usually about the following:—

Heads	... 4″ × 9″
Sills	... 4″ × 9″
Intertie	... 4″ × 7″
Braces	... 4″ × 4′ to 4″ × 7″
Door Posts	... 4″ × 4″
Uprights	... 4″ × 4″
Studs	... 4″ × 2″

Joints of Partitions.—Figures 591 to 599 show the details for the various joints and connections of partitions.

Weight of Partitions and Floors.—The following table will be found useful in determining the weight of partitions and floors:—

Spruce Fir	... 32 lbs. per foot cube.
Northern Pine ...	... 36 lbs. ,, ,, ,,
Brickwork	... 112 lbs. ,, ,, ,,
Coke Breeze Concrete (4 to 1) ...	... 72 lbs. ,, ,, ,,
Wrought Iron ...	... 480 lbs. ,, ,, ,,
Lath and Plaster ...	... 10 lbs. per foot super.

The weight of a square of partitioning may be taken at 1,480 to 2,000 lb. per square of 100 feet.

The weight of a square of single-joisted flooring without counter flooring, 1,260 to 2,000 lb. per square.

The weight of a square of framed flooring with counter flooring, 2,000 to 4,000 lb. per square.

Fixing for Plaster.—Wire netting fixed to the timber studs and expanded metal lathing about iron girders are sometimes used as the fixing for the plaster instead of wood laths, but all these methods are being superseded by the use of fibrous plaster slabs.

Regulations.—The model bye-laws require that the open space inside any partition wall of a new building or between the posts in any wall of such building be stopped with brickwork, concrete, pugging, or other imcombustible material at every floor and ceiling. With this exception, the model byelaws do not control the construction of partition or division walls which simply separate one room from another in the same house.

CHAPTER VIII.

WOOD ROOFS.

Definition.—The coverings or upper parts of buildings constructed over the enclosed space to keep rain and wind out and to preserve the interior from exposure to the weather, are called roofs. These should incidentally tie the walls and give strength and firmness to the structure.

They are built varying from almost horizontal surfaces to very steep pitches, the inclination being sometimes regulated by the climate, they should be designed to discharge any rain or snow that is likely to fall upon them. In countries favoured with mild weather, flat roofs would answer the purpose, whilst the colder climates and exposed positions would necessitate the use of steeply-pitched roofs. The latter require a greater amount of material than the flatter ones, and consequently are more expensive.

Pitch.—The steepness of a roof is usually indicated by the ratio of the rise to the span, which is known as the pitch.

Materials.—The following materials may be used as coverings for roofs. The following are the minimum inclinations as given by Hurst:—

Covering.	Angle with Horizon.	Ratio of Rise to Span.
Tin	5° 43″	$\frac{1}{20}$
Lead	,, ,,	,,
Zinc	,, ,,	,,
Copper	7 36	$\frac{1}{15}$
Corrugated Iron	11 18	$\frac{1}{10}$
Asphalted Felt	18 26	$\frac{1}{6}$
Slates, Large	22 0	$\frac{1}{5}$
,, Ordinary	26 33	$\frac{1}{4}$
Thin Slabs of Stone	,, ,,	,,
Pantiles	33 40	$\frac{1}{3}$
Plain Tiles	45 0	$\frac{1}{2}$
Thatch	,, ,,	,,

In localities exposed to much wind and rain the pitch of slates should not be less than one-third of the span. The angle of 45° is the best for slates and plain tiles, and admits of the use of the interior of the roof for the construction of garrets.

The timber used for members of roofs is usually northern pine, but for roofs of the class known as open timbered, pitch pine, oak, and chestnut.

Classification.—These may be classified in a similar manner to floors :—

(*a*) Single, consisting of common rafters, such as lean-to and couple roofs.

(*b*) Double, consisting of common rafters and purlins, such as roofs formed by common rafters, resting on purlins, supported by walls.

(*c*) Triple-membered or framed, consisting of common rafters, purlins, and trusses, such as mediæval, hammer-beam, and bracket roofs, arched rib trusses, couple-close, collar-beam, and all triangulated trusses.

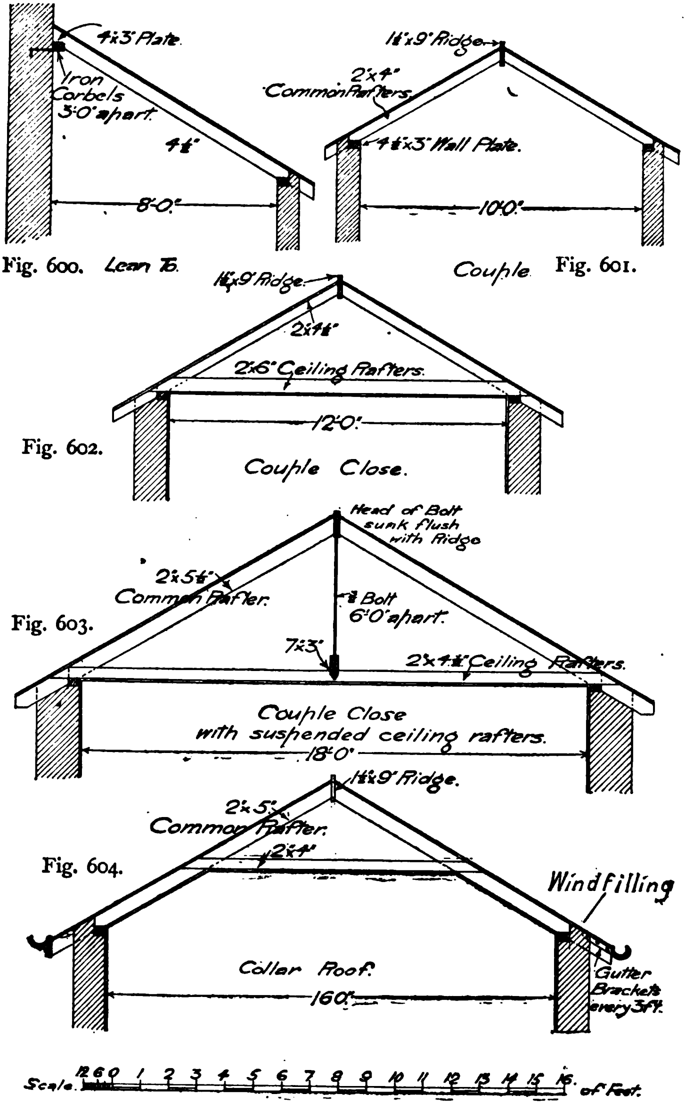


Fig. 600.

Fig. 601.

Fig. 602.

Fig. 603.

Fig. 604.

Figs. 600–604. Single-Raftered Roofs.

Amongst the numerous forms of wooden roofs, the following are considered in the elementary stage :—

Flat, lean-to or shed, couple, couple close, collar, double rafter or purlin, king-post and queen-post roofs.

Flat Roofs.—Are similar to floors, but having a water-proof top, the upper surface being constructed to drain water off, they may be made as a lead flat, as shown in figure 637, or as an asphalted concrete roof, or in other ways, but as water or snow is not thrown off, any defect will be severely tested.

Lean-to or *Shed Roofs.*—Are roofs formed with one slope only, and used for outhouses against main buildings, as in figure 600, and for sheds.

Couple Roofs.—Are roofs composed of rafters with their feet fixed to wall plates, in modern work meeting with their heads butting against a ridge piece, and without any tie except that afforded by the wall plate, no ceiling joists being used, as in figure 601. Such construction should not be used in permanent structures of greater span than 12 feet, and only for short distances between the end walls as the rafters have the tendency to thrust out the walls.

The scantlings given for couple close roofs are applicable for this method.

Couple Close Roofs.—For roofs about 12 feet in span, ties are used to prevent the walls being thrust out by the rafters. The ties are usually formed by fixing the ends of the ceiling joists to the feet of rafters, as in figure 602.

As the span increases, the tendency of the ceiling joists is to sag, to prevent this a plate is placed in the centre and on the upper surface of the ceiling rafters, and the latter are spiked to the plate, which is supported by a king bolt at intervals of about 6 feet to the ridge piece, as shown in figure 603. The space in the roof is not altogether a waste, as it acts as a screen and a non-conductor of heat to the rooms immediately underneath.

Scantlings for couple close roofs, of northern pine, rise ¼ span slated with Countess slates on boarding.

Span from centre to centre of Wall Plate.	Rafters.	Ridge Board.	Ceiling Joists.	REMARKS.
8 feet	3 × 2	7 × 1½	4 × 2	
10 ,,	3½ × 2	7 × 1½	5 × 2	
12 ,,	4 × 2	7 × 1½	6 × 2	
14 ,,	4½ × 2	7 × 1½	7 × 2	If these spans have a king bolt as shown in figure 603, the depth of the ceiling joists may be reduced to one half of these dimensions.
16 ,,	5 × 2	8 × 1½	8 × 2	
18 ,,	5½ × 2	8 × 1½	9 × 2	

Collar Roofs.—Roofs of this description are constructed by fixing wood ties half way up to the rafters, to support them, and carry ceilings which are attached to the underside, and the lower part of rafters, as shown in figure 604. If the wall plates are securely fixed in the walls, and the latter are of an ordinary thickness, this method answers without ties, and has the advantage of adding extra height to the room below; but directly the wall plates give, the collars become stretched owing to the feet of rafters spreading, and the result is that the walls have the tendency to fall outwards, besides which the non-conductivity of heat is reduced, as compared with the preceding method.

Scantlings for collar beam roofs of northern pine, collar half way up without a tie, rise ¼ span slated with Countess slates on boarding. If the pitch is 45°, add 1 inch to the depth of the rafters.

Span from centre to centre of Wall Plate.	Rafter.	Ridge.	Collar.	REMARKS.
8 feet	3 × 2	7 × 1½	3 × 2	
10 ,,	3½ × 2	7 × 1½	3½ × 2	
12 ,,	4 × 2	7 × 1½	4 × 2	
14 ,,	4½ × 2	7 × 1½	4½ × 2	If there is no ceiling the collars may be reduced in depth, but they should be made thicker to prevent side buckling, as they will no longer be stiffened by the lathing.
16 ,,	5 × 2	7 × 1½	5 × 2	
18 ,,	5½ × 2	7 × 1½	5½ × 2	

Double Rafter or *Purlin Roofs.*—Above 18 feet span the roofs already described will not answer unless the timbers are abnormally large, the expense and unsightliness of which prohibit their use. Above that length of span either purlin or framed roofs should be used. If an intermediate support can be obtained as in the majority of dwelling-houses, purlin roofs, as shown in figures 605 to 607, may be used with advantage. Figure 605 shows a type of purlin roof in which the space inside the roof is not intended for use; the ceiling joists should be in one length or connected over a partition by lapping and nailing, to form a tie for each pair of common rafters; at the extremities of ceiling joists plates for fixing the feet of rafters are nailed. Half way up the length of the rafters purlins are fixed, having a support on the gable wall at each end, and obtaining intermediate supports at intervals not greater than 6 feet apart by collars placed under the purlins and nailed to the rafters, and also by braces nailed to the collar and butting at the lower extremities on a plate nailed to the ceiling joists.

Figure 606 shows a type of purlin roof in which the space inside the roof is utilised; the floor joists extend from wall to wall, being lapped and nailed over the partition wall about the centre. The construction is similar to that previously described. Beneath the upper purlins a collar is nailed to every pair of rafters and acts as a ceiling joist. The lower purlin is framed as a common partition, and forms what is known as the ashlaring. Dotted lines indicate the position in which dormers would be fixed.

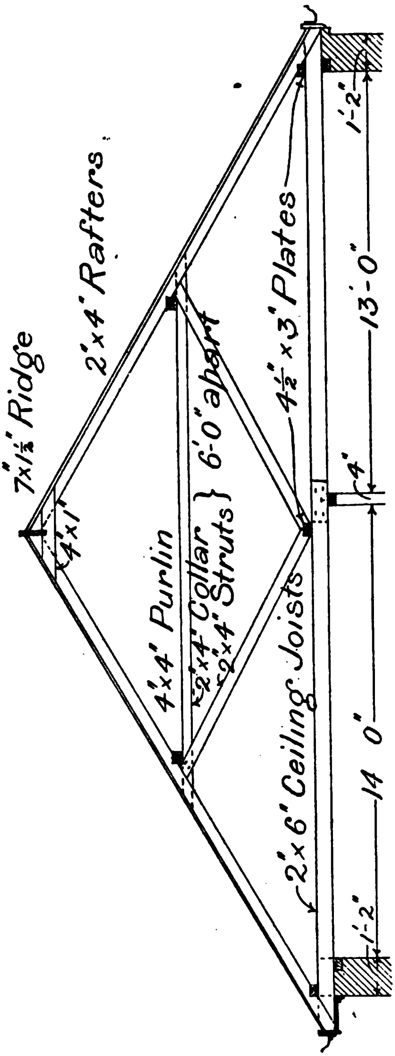


Fig. 605.

Figure 607 is what is known as a curb **M** roof. Its construction follows the principles already described in the two immediately preceding examples. The valley gutter is drained by a trough or box gutter or lead pipe as indicated by dotted lines.

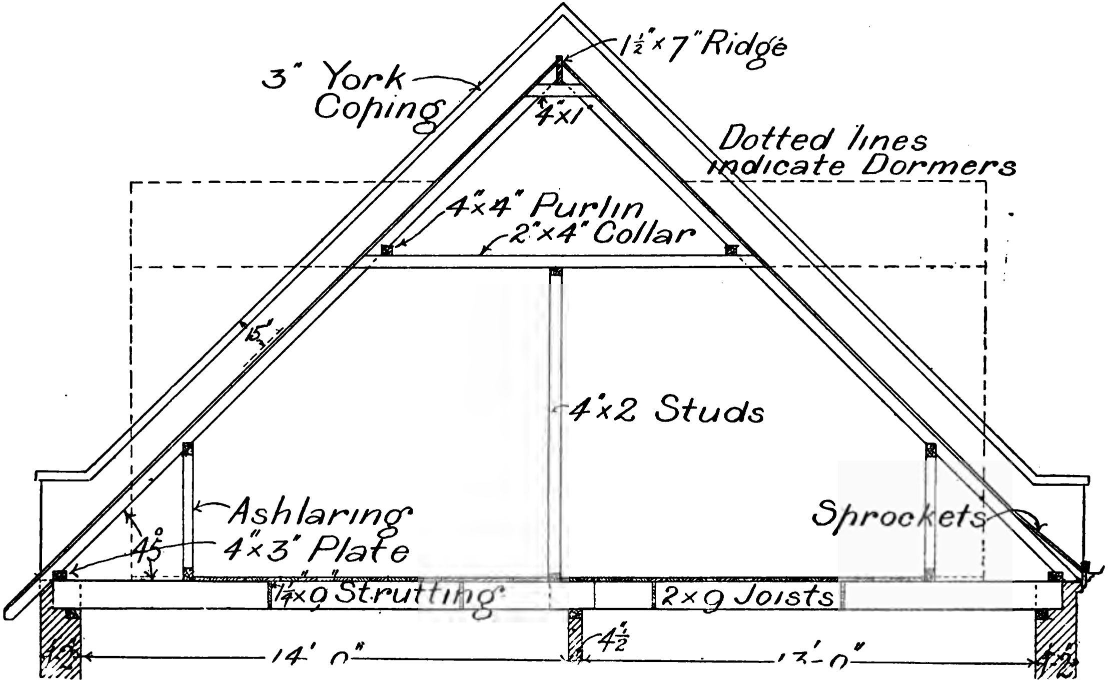


Fig. 606. Type of Purlin Roof in which the space inside the Roof is utilised.

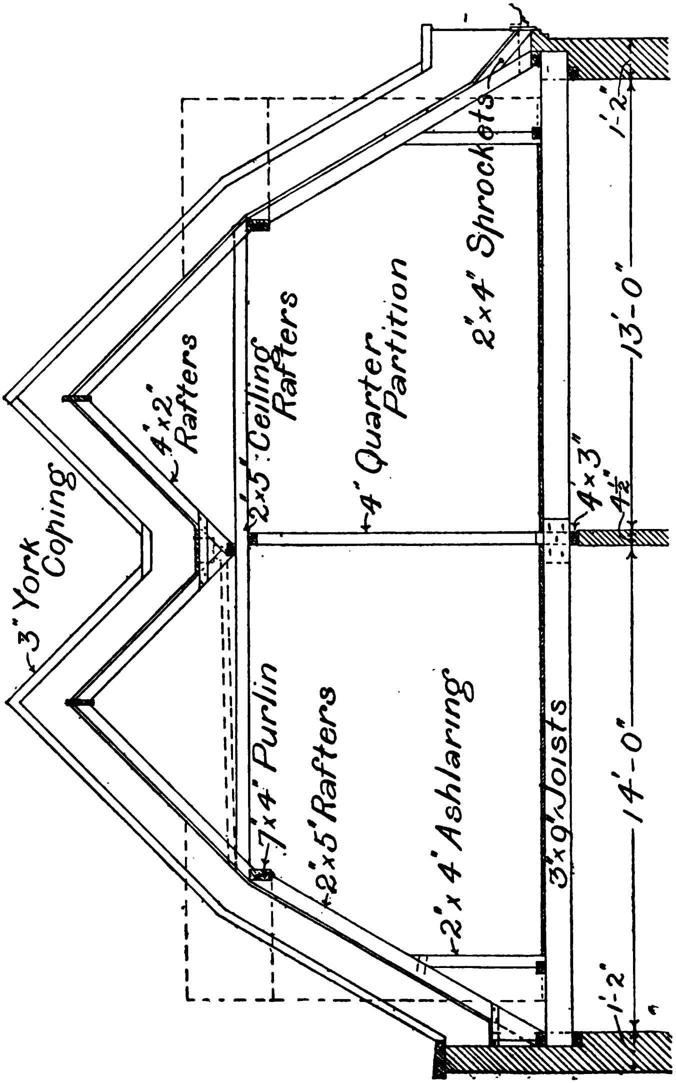


Fig. 607. Example of Curb **M** Roof.

The upper M-shaped portion is often omitted and a flat constructed. There is less height and, consequently, less brickwork required in gables, party walls, and chimney stacks, but the rooms in such roofs are more susceptible to the variations of the external temperature.

Construction of Trusses.—The theory of trussing has already been given in the chapter on partitions

Trusses are usually arranged at a distance of not more than 10 feet apart. When it is desirable to have the trusses a greater distance than 10 feet apart, trussed purlins would be used to support the roof coverings, and distribute the weight on the trusses.

The trusses are timbers framed together, and consist of principal rafters, tie beam, posts, and struts. These frames carry purlins and sometimes pole plates, which in their turn support the common rafters, and should be so constructed that every member is in direct tension or compression (with the exception of the tie beams carrying ceilings), the reason being that timber can resist very much greater loads when in direct tension or compression than when subject to transverse stress. This advantage is gained by designing triangulated frames, and arranging that the loads are supported at the angular points of the triangles. In setting out these frames it is wise to draw first the centre line of all the principal members, and to arrange the intersection of the centre lines of principal rafter and tie beam immediately over the centre of bearing, or within the middle third of the supporting wall.

The truss should be so arranged that the distances between the supporting points of the principals, or the unsupported lengths of common rafters, are not more than 8 feet. The king-post form would thus be applicable for a roof with a principal rafter 16 feet long, or for a span of 28 feet. The best position for purlins is directly over the joints of principal rafters and their struts, and for the feet of principal rafters

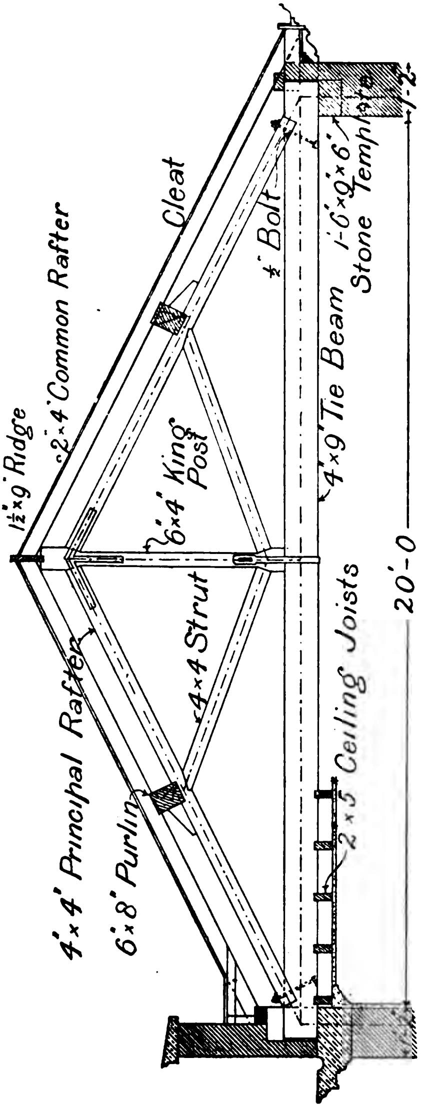


Fig. 608.

directly over their supports, and the struts should be inclined to the horizontal as much as possible, and their feet on king-posts, kept as low down as is practicable, as shown in figure 608; the ends of tie-beams should not be built into walls, so as to come in direct contact with the brickwork, which is more or less damp, according to the hygrometric state of the atmosphere, but should be so arranged where the tie beam supports the ceiling, that the timbers of roofs are just sufficiently ventilated to prevent the dry rot without destroying the valuable non-conductive properties of the comparatively still dry air chamber.

Figure 608 gives an illustration of a king post roof-truss for 25-feet span, showing methods of arranging timbers to form taper-shaped parapet and eaves gutters. In London and adjoining districts all external walls, if adjoining gutter, to have parapet walls, at least one brick thick, 12 inches high, the height being measured from highest point of gutter, and party walls to have parapets 15 inches high above roof. The sole piece of taper-shaped gutters should never be less than 9 inches at lowest point, so as to be wide enough for a man to stand upon it

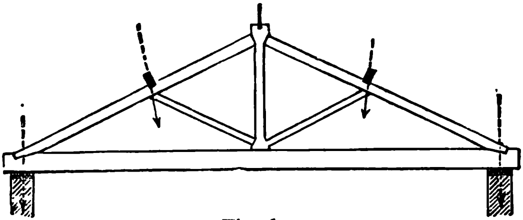


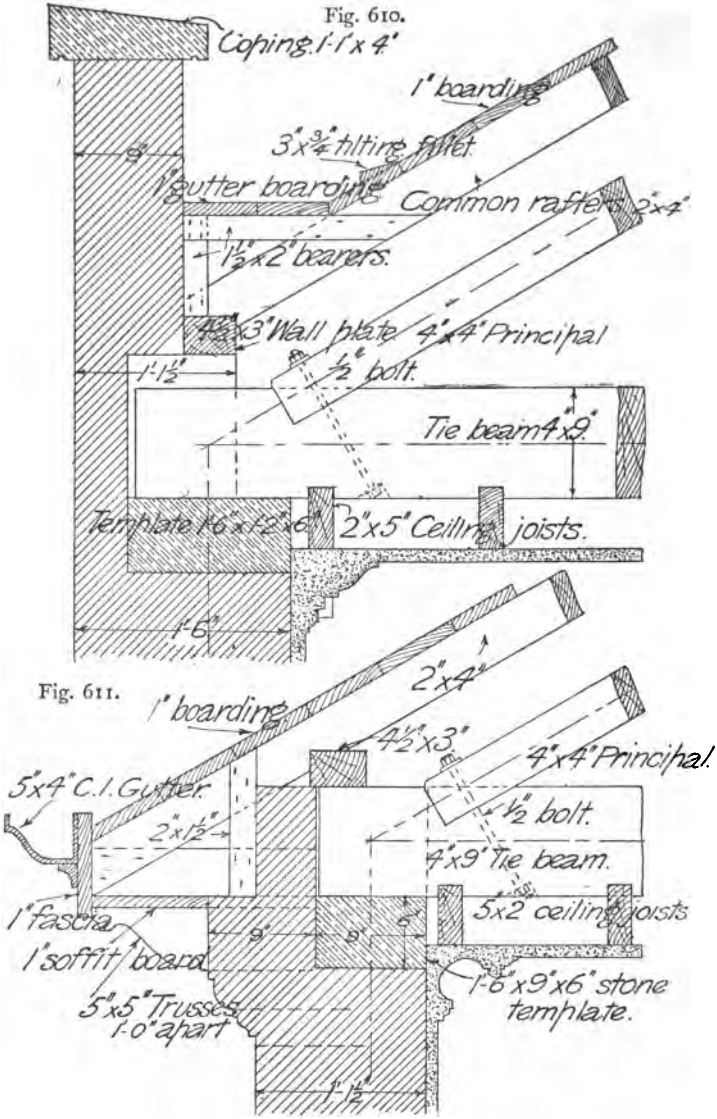
Fig. 609.

Feet of Principal Rafters.—These should rest immediately over the walls, as in figures 608 and 619, the best position being the centre line of rafter meeting the centre line of tie-beam perpendicularly over centre of support, as in figure 608.

Tie-beams.—It is advisable to let the ends of tie-beams rest on stone templates, over thickness of walls, or even project somewhat over where possible, as in eaves roofs, so that the load may be taken directly by the walls; but whichever method is adopted, care should be taken to ensure a sufficient circulation of air, to prevent timbers being attacked by the dry rot. This may be accomplished by having dormers with louvre boards, or by purposely formed ventilating fleches with louvre boards fixed at highest parts of roofs, as shown in the chapter on roofs in my "Advanced Course," or, in roofs for stations, workshops, etc., where plenty of ventilation is no objection,

Fig. 610.

Fig. 611.



Figs. 610, 611. Wall Plates, Gutter Bearers and Eaves Gutters.

by having open soffits to the eaves, and by various other methods which may suggest themselves.

Pole Plates are timbers acting as girders supported only by the trusses, carrying the feet of common rafters, and are necessary where parallel gutters are to be formed, as in figure 908, or where all the load must be carried by the piers or portions of walls supporting the tie-beams.

Wall Plates.—If taper-shaped or eaves gutters are to be constructed, the brickwork may be built up to carry wall plates, as in figure 610, instead of using pole plates, thus receiving and distributing equally a portion of the load of the roof directly on to the walls.

Gutter Bearers.—The gutter boards, usually 1 inch in thickness, may be supported by 1½-inch by 2-inch, or 3-inch by 2-inch gutter bearers, which are halved and nailed to every rafter, as shown in figure 610.

Eaves Gutters.—One method of forming eaves gutters is shown in figure 611, and shows a wall plate directly supported by the wall.

Head of Principal Rafter.—Figure 613 shows a method of forming the junction of principal rafter with the king-post by a single shoulder, and which may be secured by three-way straps, as shown in figure 613.

Ridge Boards are the highest timbers of roofs, they form the abutments for the heads of common rafters, which are usually spiked to them, but in good work are housed in. The ridge board may be held in position by slotting the head of the king-post, as in figure 613.

Fig. 612.

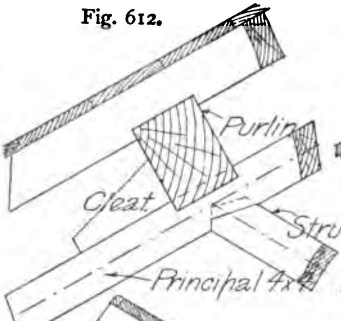
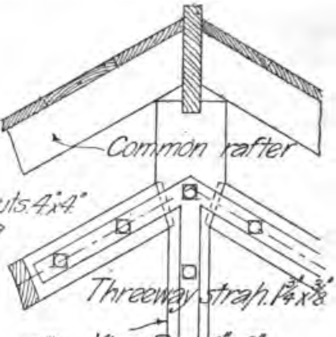


Fig. 613.



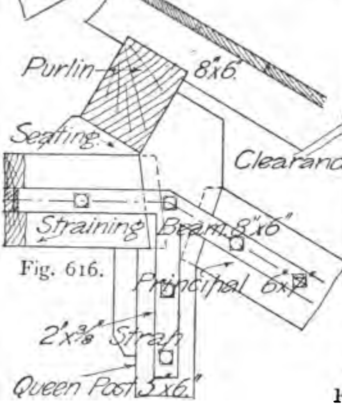


Fig. 616.

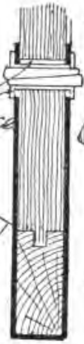


Fig. 615.

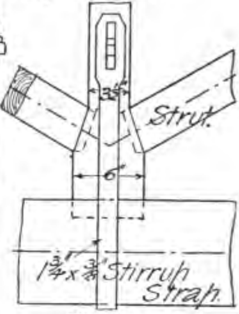


Fig. 614.

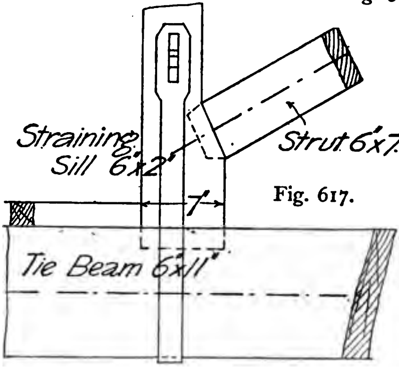


Fig. 617.

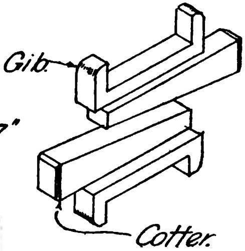


Fig. 618.

Figs. 612–618. Details of Wood Roofs.

Struts and King-post Joint.—This is made similar to the joint at the head of principal rafter and king-post; the width of the foot of the king-post is usually sufficient to admit of the joint shown in figure 614, which, being simple and easy to make, should always be used.

King-post and Tie-beam Joint.—These are sometimes held together by bolts only, or by straps secured with bolts, the tie-beam being brought to the required camber by ropes suspended from the ridge (1 inch in 20 feet generally being considered sufficient to prevent any unsightly settlement), the shoulders of king-post having been cut to the required length, but the best arrangement is that of gibs and cotters, which allow the joint to be drawn up at any time an open shoulder is observable, by leaving clearances, as shown in figures 614 and 615.

Purlins.—The horizontal members of the roof, supported by the trusses, and which carry the common rafters between the pole or wall plates and the ridge piece. They should not be more than 8 feet from the next support of common rafters, and should be cogged to the principal rafters directly over the struts. In some forms of roofs, where common rafters are dispensed with, they carry the boarding to receive slating, as in figures 623 and 660.

Junction of Struts and Principal Rafters.—These may be arranged as in figure 612, and are sometimes held together by straps, and should be placed directly under the stress transmitted by the purlin above, as in figure 609; the latter distributing the load from roof above when acted on by the wind on that side.

Common Rafters.—The sloping timbers to which roof coverings are attached. In framed roofs they are supported by

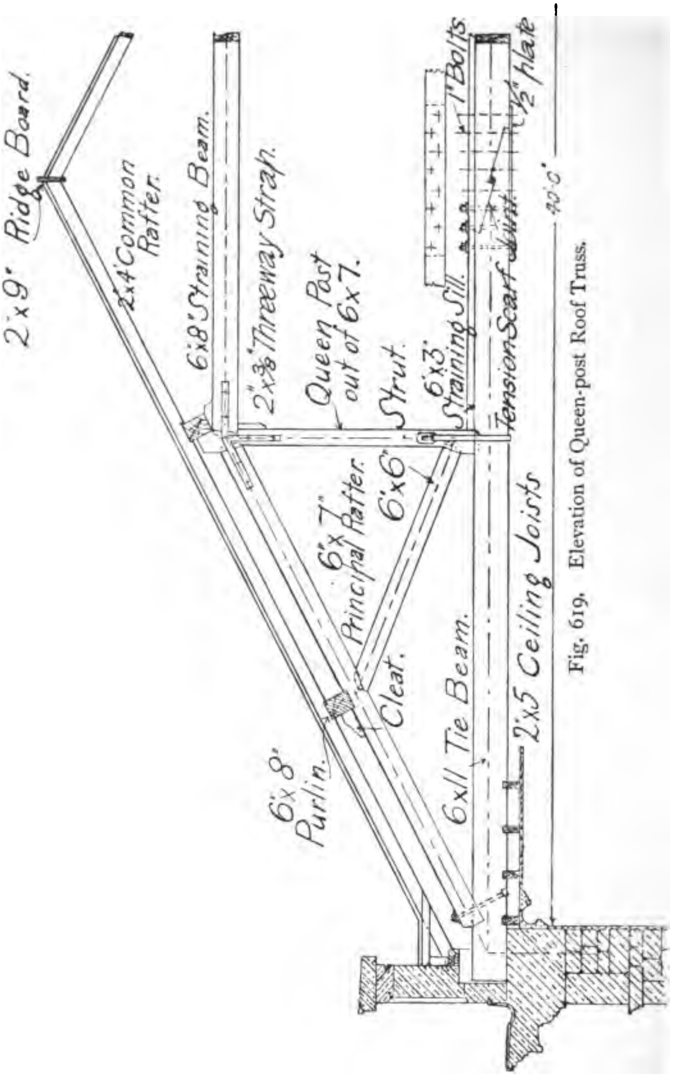


Fig. 619. Elevation of Queen-post Roof Truss.

pole or wall plates, purlins and ridge pieces, and should not have an unsupported length of more than 8 feet, they should not be in plan more than 15 inches apart, and are generally arranged to clear the heads of king-posts. Common rafters should have a minimum thickness of 2 inches and a depth of 4 inches. If the span is greater than 8 feet they should be increased in depth ½ inch for each foot in excess.

Cleats.—Pieces fixed on principal rafters, straining beams, etc., to prevent purlins tilting, and are usually simply spiked on, as in figure 612, but in very good work may be housed.

Sprocket Pieces.—The upper surface of the common rafter is often made concave by planting pieces of timber of the same breadth as the common rafter of curved shape in elevation, termed sprocket pieces, at the feet of rafters, as shown in figures 606 and 607. This allows of slate or tiled coverings to fit with closer joints on their tail ends. Sometimes sprocket pieces are used to improve the appearance of roofs.

Wind Filling.—The brickwork that is carried up between rafters to the underside of the roof boarding, as shown in figure 604.

Queen-post Roof Truss.—Figure 619 shows an elevation of same, suitable for spans from 30 to 45 feet, the parts being easily understood from what has been already stated about the king-post truss. The tie-beam, if of northern pine, is usually in two lengths, and scarfed. A straining sill is sometimes fixed between queen-posts to act as an abutment for the queen-posts, and as a fish-plate to the scarf joint.

Figures 616 and 617 show the joints at the head and foot of a queen-post truss. The joints are similar to those already explained for the king-post truss.

Scantlings for wood roofs, of northern pine—trusses 10 feet apart, ¼ pitch, slate covering *(Hurst's Handbook)*:—

Span in feet.	Tie-beam.	King-post.	Queen-post.	Principal Rafters.	Straining Beam.	Struts.	Purlins.	Common Rafters.
20	9½×4	4×3	—	4×4	—	3½×2	8×4¾	3½×2
22	9½×5	5×3	—	5×3½	—	3¾×2¼	8¼×5	3¾×2
24	10½×5	5×3½	—	5×4	—	4×2½	8½×5	4×2
26	11½×5	5×4	—	5×4¼	—	4¼×2½	8¾×5	4¼×2
28	11½×6	6×4	—	6×3½	—	4½×2¾	8¾×5¼	4½×2
30	12×6	6×4½	—	6×4	—	4¾×3	9×5½	4¾×2
32	10×4½	—	4½×4	4½×6¾	6¾×4½	3¾×2¼	8×4¾	4½×2
34	10×5	—	5×3½	5×6½	6¾×5	4×2½	8¼×5	3¾×2
36	10½×5	—	5×4	5×6¾	7×5	4¼×2½	8½×5	4×2
38	10×6	—	6×3¾	6×6	7¼×6	4½×2½	8½×5	4×2
40	11×6	—	6×4	6×6½	8×6	4½×2½	8½×5	4¼×2
42	11½×6	—	6×4½	6×6¾	8¼×6	4½×2¾	8¾×5¼	4½×2
44	12×6	—	6×5	6×7	8½×6	4½×3	9×5	4¾×2
46	12½×6	—	6×5½	6×7¼	9×6	4¾×3	9×5½	5×2

The following gives the nature of the stresses that the members of king and queen-post roofs are calculated to resist.

Compression.—Principal rafters, straining beams, struts.

Tension.—King-posts, queen-posts, tie-beams without ceilings attached.

Transverse or Cross.—Purlins, common rafters.

Transverse and Tension.—Tie-beam with ceiling attached.

CHAPTER IX.

COMPOSITE ROOFS.

Definition.—Roof trusses built up of timber and iron members are known as composite trusses.

Composite Trusses.—The ties of trusses in composite roofs are often constructed of wrought iron or steel, because the latter has greater tensile strength than timber; moreover, the rectangular section in beams is wasteful, as the mortices or housings made at the joints in cutting the fibres considerably reduce the effective sections, consequently large pieces of timber have to be used to do the required work; this adds great weight to be carried by the supports, and interrupts the passage of light in open roofs. Wrought iron and steel ties would undoubtedly be oftener employed if it were not for the trouble and delay caused in getting small quantities executed, and the difficulty in fixing ceiling joists where such are required. Suspending the ceiling joists by iron straps to the ties is a somewhat unsatisfactory method, though sometimes adopted.

Objection.—Composite roofs of wood and iron are subject to this objection, that the timber principals neither expand nor contract appreciably with the changes of temperature, while the iron members do so considerably. This can easily be imagined to have the effect of lengthening the tie until it ceases to act, or until the feet of the principal rafters spread; or, again, the contraction of the iron tie rod may have the effect of bending wood principals or overstraining the tie rod.

Tie-beams and Principal Rafters.—In open roofs, iron ties may be advantageously used, but ceiling joists are more easily

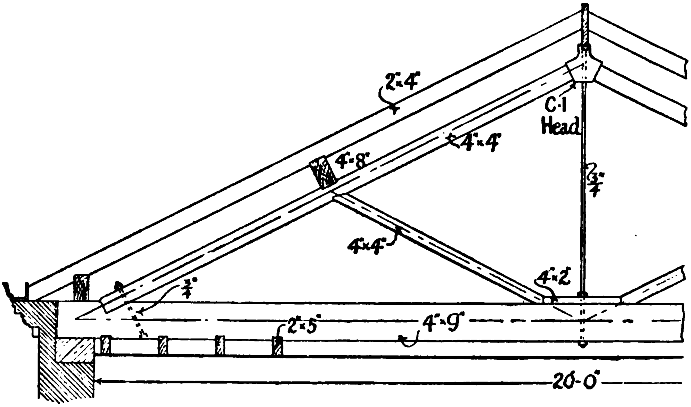


Fig. 620.

fixed to timber tie-beams. The principal rafters in composite roofs are always of timber, owing to the facility with which purlins may be fixed, and to the high resistance of rectangular sections of timber to compression.

Typical Trusses.—The following are typical composite trusses:—For spans of from 20 to 30 feet.

Figure 620 shows a wrought-iron king bolt and cast-iron head, the joint at the foot of the struts being made by introducing a straining piece. Figure 621 illustrates a truss for a 20-feet span, the tensional members being of wrought iron, while the struts and principal rafters are of timber. All the connections in this truss are such as can be made by an ordinary smith.

The German truss, as shown in figure 622, may be used,

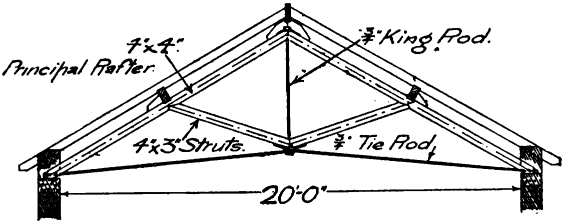


Fig. 621.

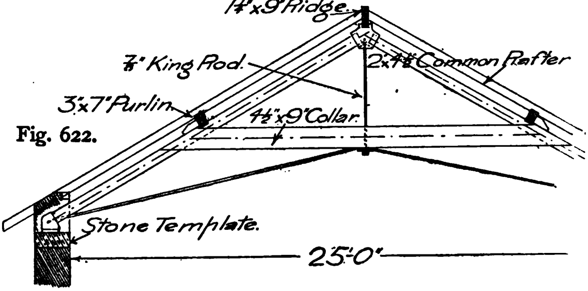


Fig. 622.

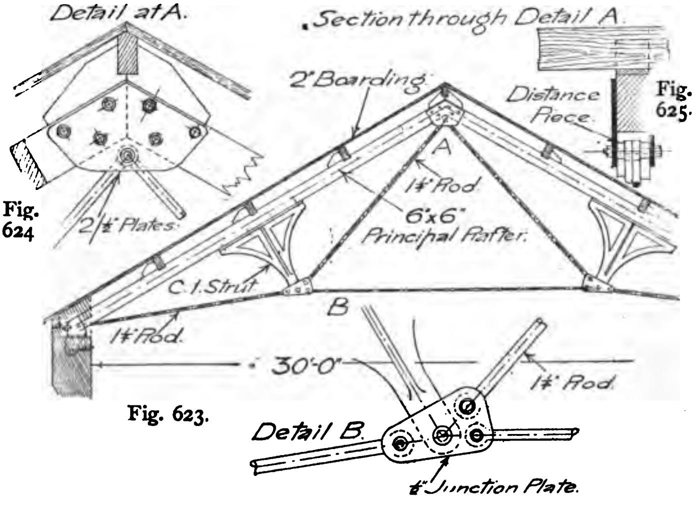


Fig. 625.

Fig. 624

Fig. 623.

Fig. 626.

Figs. 621–626. Composite Trusses.

where it is desirable to gain increased height in the chamber below, introducing a king bolt and tie-rods, those being the members in tension.

This form follows the lines of the timber collar beam truss, but with tie-rods to overcome the horizontal thrust instead of the wood gusset pieces, shown in the chapter on roofs in my "Advanced Course."

There is a cast-iron shoe at the connection between the principal and the tie-rod, also a cast-iron head to receive the upper ends of principals.

Figure 623 shows wrought-iron or steel tension and tie-rods with cast-iron struts, the principals alone being of timber. There is a cast-iron shoe at the joint between principal and tie-rod. The junction at heads of principal rafters is secured by two $\frac{3}{8}$ iron gusset plates bolted through: these form a fork to receive the upper ends of tie-rods. The ridge board is supported by cleats nailed on to principal rafter, as shown in figure 624.

Figures 624 to 626 show details of the joints.

For spans from 30 to 40 feet, the king bolt and queen bolt forms of truss may be used, those members being of wrought iron and constructed as illustrated in figure 628. The tie-beams being of timber and well tied up by the king and queen bolts, render these trusses suitable for supporting a ceiling.

Feet of Principal Rafters.—Iron ties may be secured to wood principals by the aid of a cast-iron shoe, which receives foot of principal, and is drilled to receive tie as illustrated in figure 631. The feet of principal rafters are at times received by a cast-iron shoe fixed to the wooden tie beam as shown in figures 633 and 634.

Head of Principal Rafter.—Cast-iron heads are made to form the abutment for the upper ends of principal rafters, with a hole cast for the king bolt to pass through, as shown in figures 629 and 630.

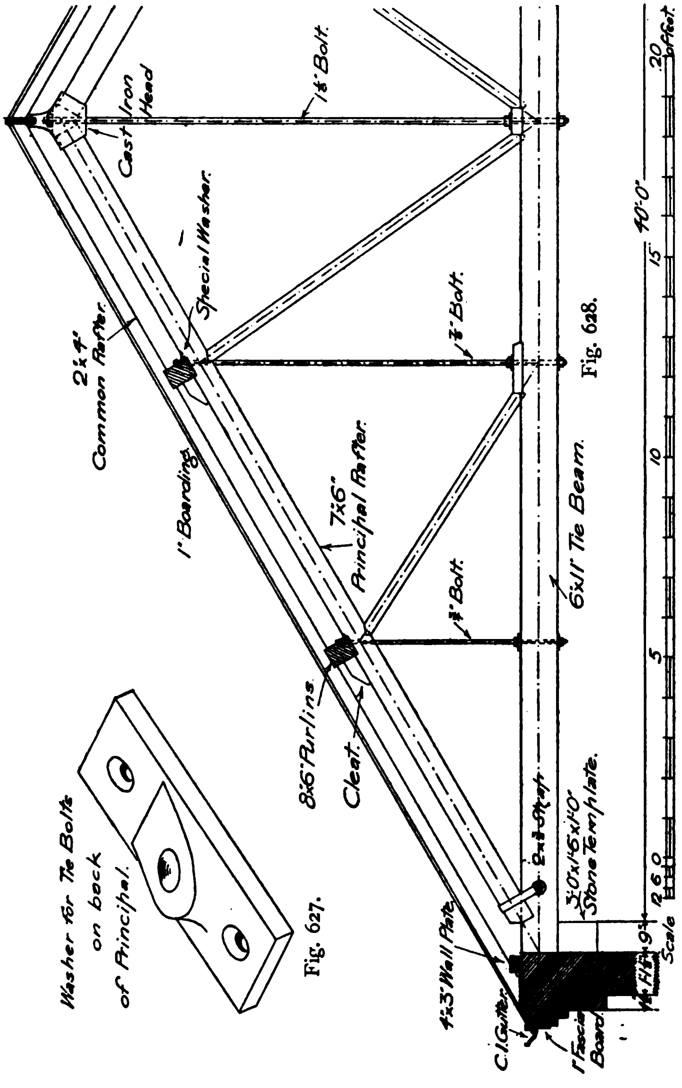


Fig. 627.

Fig. 628.

Figs, 627, 628.—King and Queen-Bolt Truss.

Fig. 629. Fig. 630.

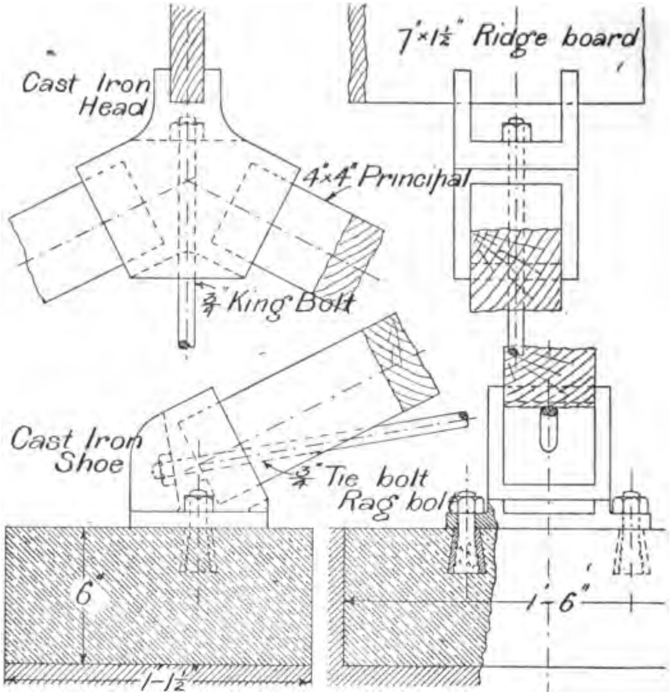


Fig. 631. Fig. 632.

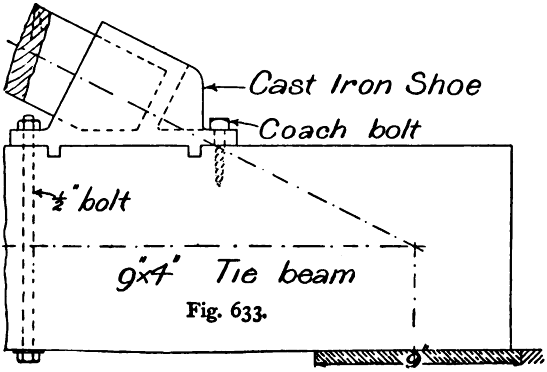


Fig. 633.

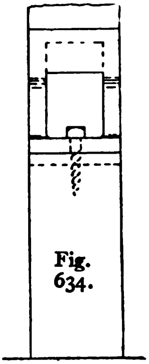
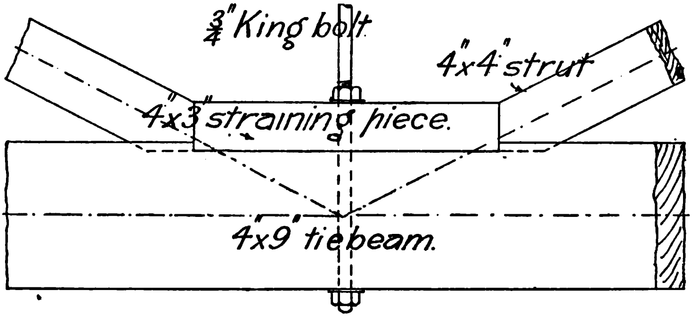


Fig. 634.

Figs. 629-634. Cast-iron Heads and Shoes.

Timber Strut, Principal and Queen Bolt.—The usual joint between the strut and principal is a single abutment with queen bolt passing through a hole bored through the principal, and fixed by a nut screwed on bevelled washer to back of principal, as shown in figure 627.

Fig. 635.



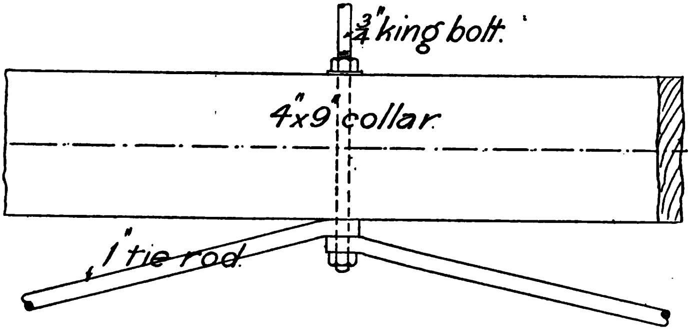


Fig. 636.

Feet of Struts.—This joint may be made by fixing a straining piece, as shown in figure 635, timber struts and tie-beam being used.

Feet of King or Queen Bolts.—These may pass through the straining pieces, which are indented into the tie-beam and receive the wood struts. The tie-beam is secured by screwed nuts and washers on king bolt over straining piece and under tie-beam, as illustrated in figure 635.

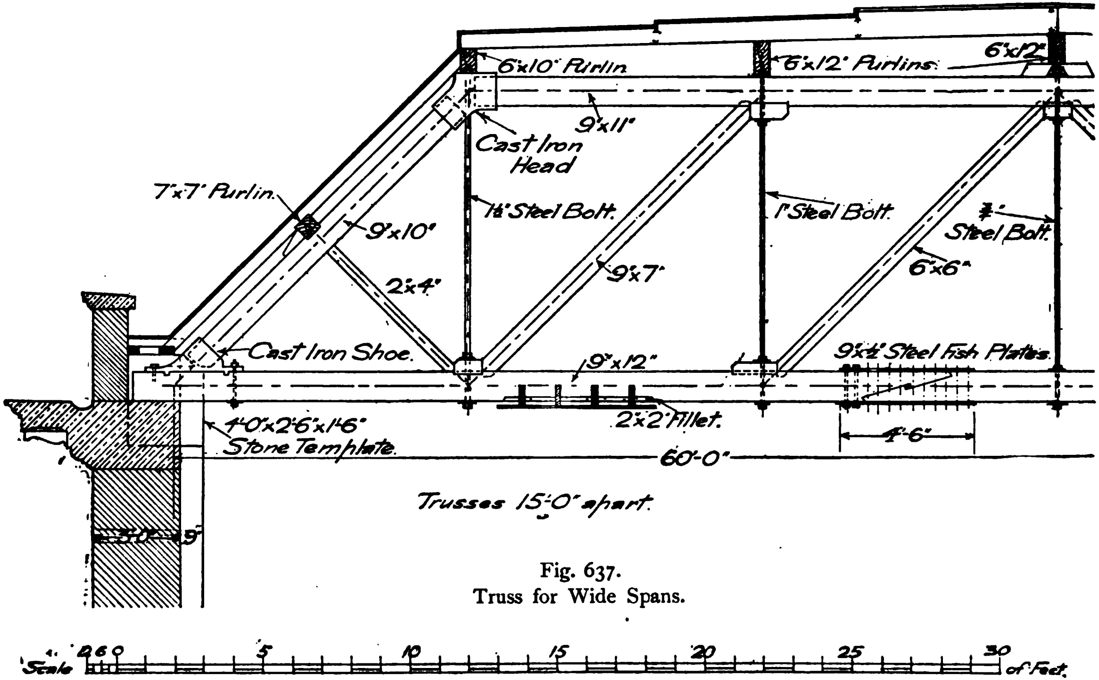


Fig. 637.
Truss for Wide Spans.

N *Truss.*—Wide spans may be effectively bridged by composite trusses built up in the form of an **N** girder, in which the long members are in compression and the short members in tension. It may be noted that in such type of structures in iron or steel, the long members are usually arranged as ties, and the short as struts.

Figure 637 shows a truss on this principle suitable for an effective span of 60 feet. The upper covering has been arranged for a lead flat.

CHAPTER X

IRON ROOFS.

Iron Roofs.—The great superiority of iron and mild steel over timber in stress-resisting properties, the great varieties of economical and suitable sections in the market, the ease with which they can be packed and transported, and their resistance to fire and insects, have caused them to gradually displace timber as materials for roofs of large or even moderate dimensions, and great attention has been given to the most economical methods of designing them.

Stresses on Trusses.—Every member of a truss should be in either direct tension or compression; but in smaller roofs the purlins are often distributed along the length of a principal rafter, causing it to be in transverse stress; in that case the distance between struts should not be great, otherwise the principal rafter will have to be wastefully large. Struts should be arranged as short as possible, and as many braces as possible be in tension.

Cast Iron can be advantageously employed for shoes and short struts.

Wrought Iron and mild steel are sometimes employed for every part of the truss, as illustrated in figs. 644 to 651.

Mild Steel is used for every part for which wrought iron may be used, but with reduced sections.

Riveting and Bolting.—In making the connections with members, rivets may be employed up to 1 inch in diameter, but where a larger diameter is required bolts are used; the latter are more expensive, but have the advantage of allowing the roof to settle somewhat, and the joints to adjust themselves under the load.

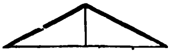


Fig. 638.
Span 15 ft. to 20 ft.

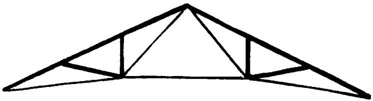


Fig. 641.
Span 30 ft. to 40 ft.

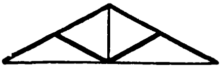


Fig. 639.
Span 20 ft. to 30 ft.

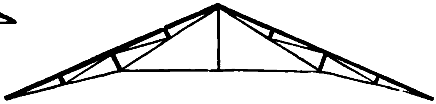


Fig. 642.
Span 40 ft. to 50 ft.

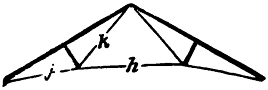


Fig. 640.
Span 20 ft. to 30 ft.

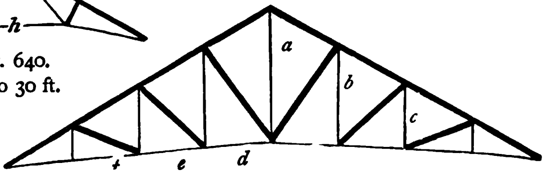


Fig. 643.
Span 40 ft. to 50 ft.

Typical Trusses.—Figures 638 to 643 show outlines of iron trusses for spans, varying from 15 to 50 feet. Thin lines indicate the members in tension, thick lines in compression.

The following table gives the dimensions of heads and nuts square and hexagon for bolts in the ratio of the diameter of the bolt. Figures 463 to 467 illustrate these:—

	Diameter of Head and Nut between Faces.	Diameter of Head and Nut across Angles.	Thickness of Head.	Thickness of Nut.
Hexagon	1·75	2	·75 to 1	1
Square	1·5	2·12	·75 to 1	1

The following table gives the dimensions of the various rivet heads in the ratio of the diameter of the shank, and are shown in figures 459 to 462:—

	Diameter of Head.	Thickness of Head.
Cup	1·7	·6
Countersunk...	1·6	·4
Pan head	1·6	·7
Conical	2	·75
Conoidal	2	·7

Hipped Roofs.—Trusses with perpendicular members are considered better for the trusses of hipped roofs.

Sections to resist Tension.—These may be round, or one or more flat bars with their greater dimension vertical, which form has the advantage of sagging or deflecting less under its own weight.

Sections to resist Compression.—Angle iron, tee iron, and channel iron are generally used. Double channel iron, kept apart by pipe distance pieces with small bolts passing through and riveted at ends, forms a stiff section, but is more costly than tee iron. Angle irons kept in a similar manner render the connections easy to make. Flat-bar iron, kept apart by

Iron Roof Truss for 20-ft. Span.

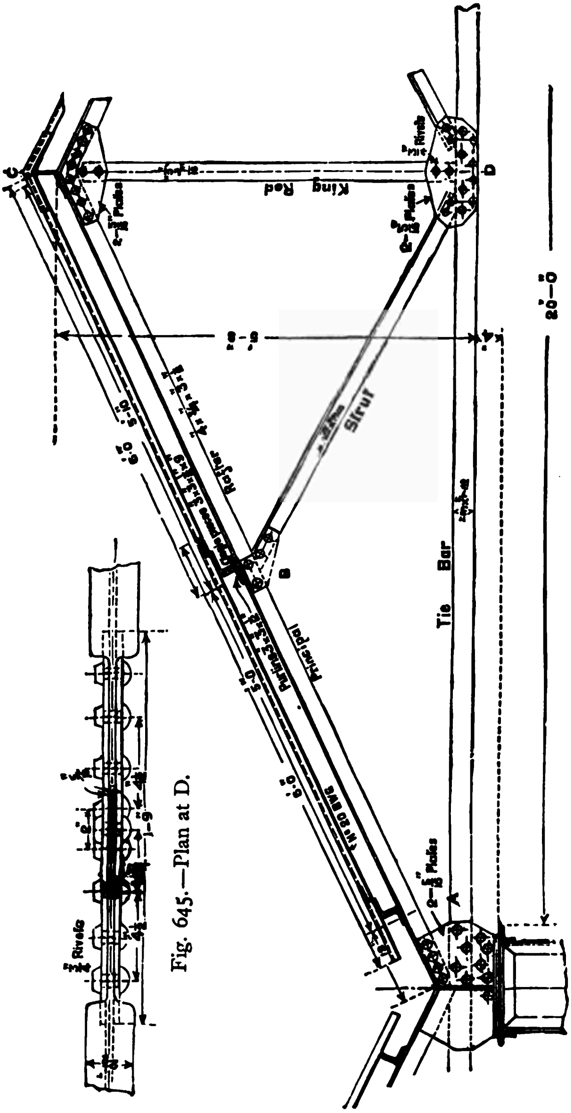


Fig. 644. Half Elevation.

Fig. 645.—Plan at D.

Detail at A

Fig. 646.

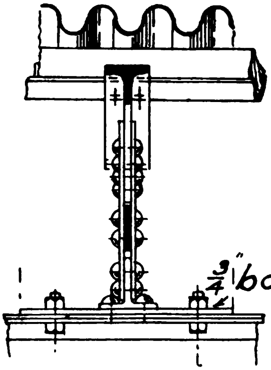
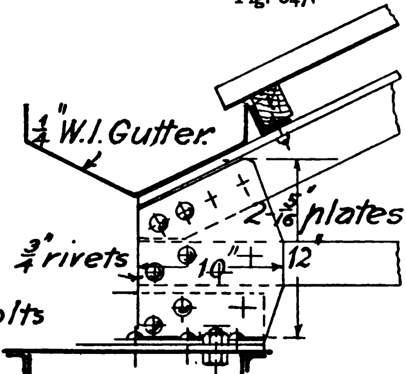


Fig. 647.



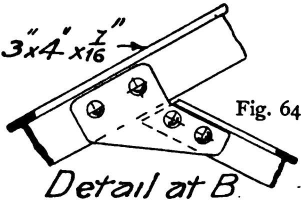


Fig. 649.

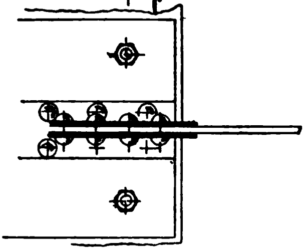
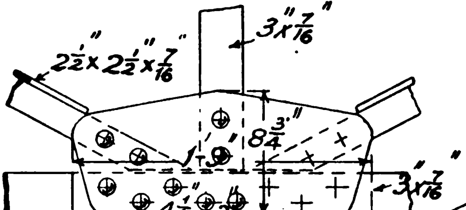


Fig. 648.



Detail at D.

Fig. 650.

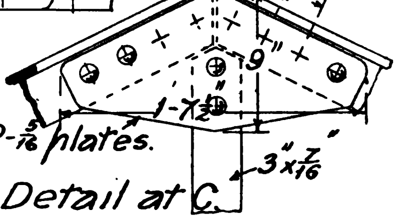


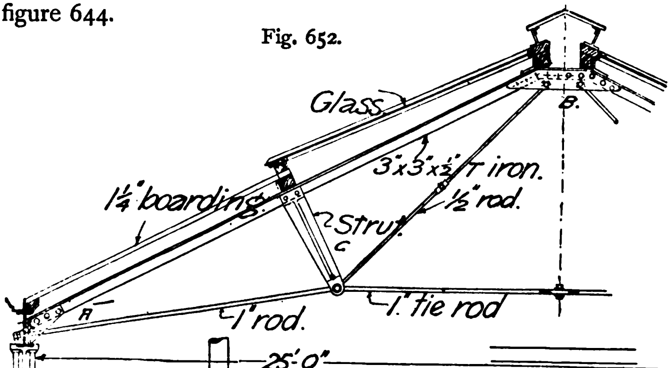
Fig. 651.

Figs. 646–651. Details of Joints.

distance pieces so arranged as to bulge them out in the centre and secured by rivets, forms a good and simple joint, as shown in figure 669. Short struts may be made of cast iron of cross section with forked ends, as in figure 666, for a bolt to pass through and form the connection.

Sections under Transverse Stress.—Rolled iron joists, as in figure 686, angle or tee irons, are used for purlins, as in figure 644.

Fig. 652.



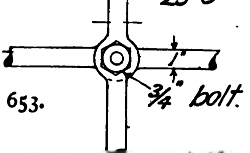
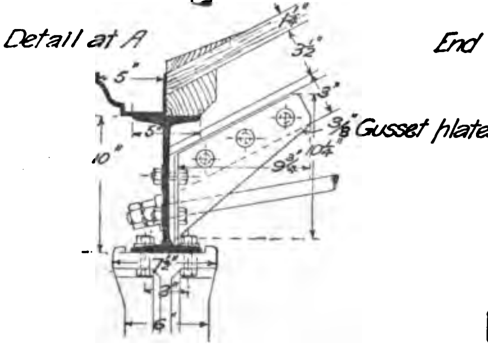


Fig. 653.



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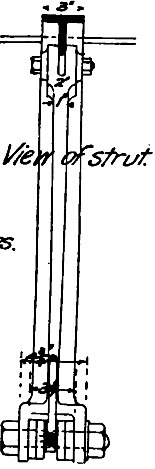

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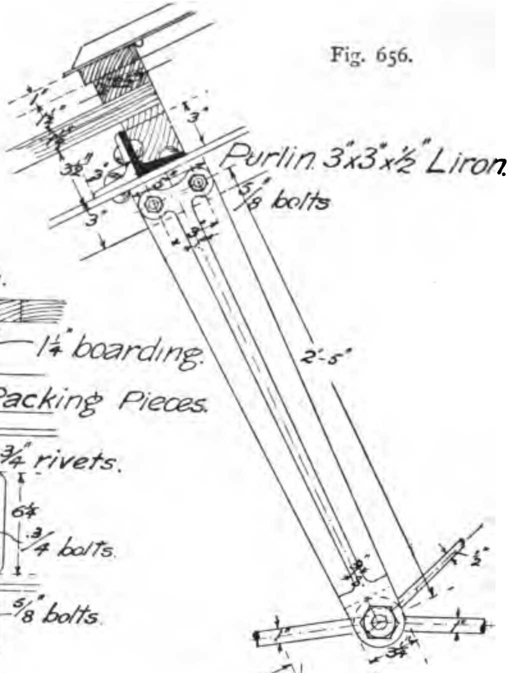
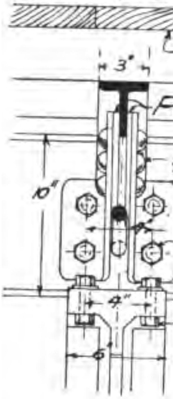
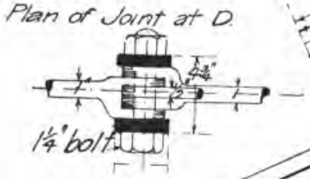


Fig. 656.

Fig. 657.





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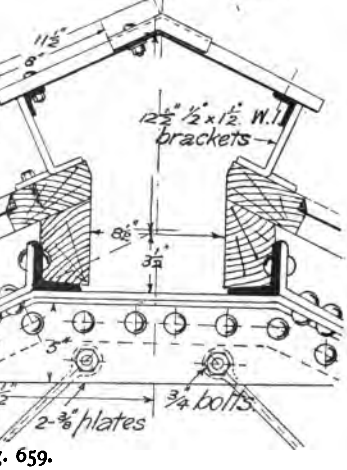


Fig. 659.

Figs. 656-659. Details of Joints.

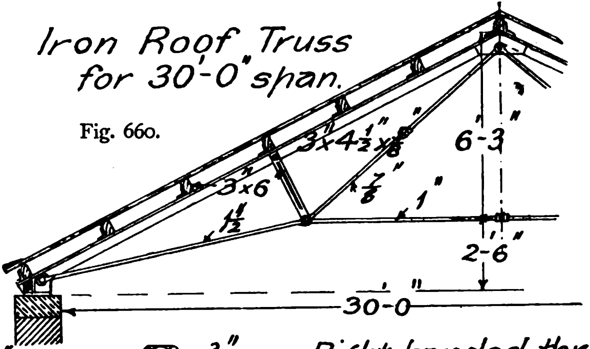
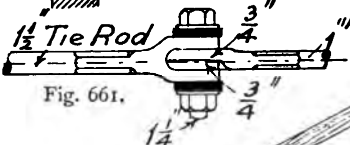


Fig. 660.



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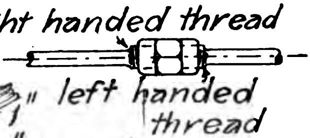

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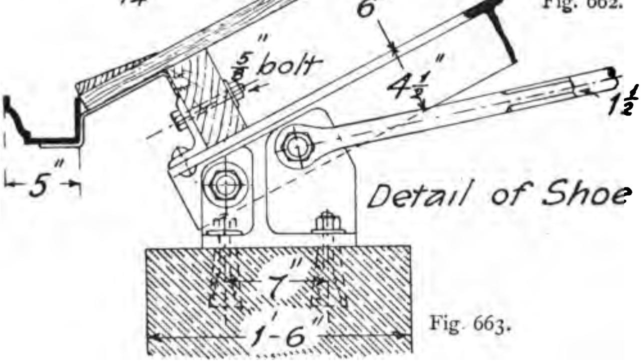

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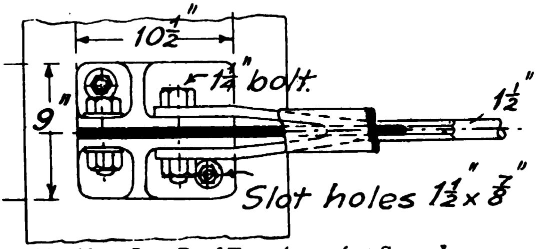


Fig. 664.

Figs. 660-664. Iron Roof Truss for 30-feet Span.

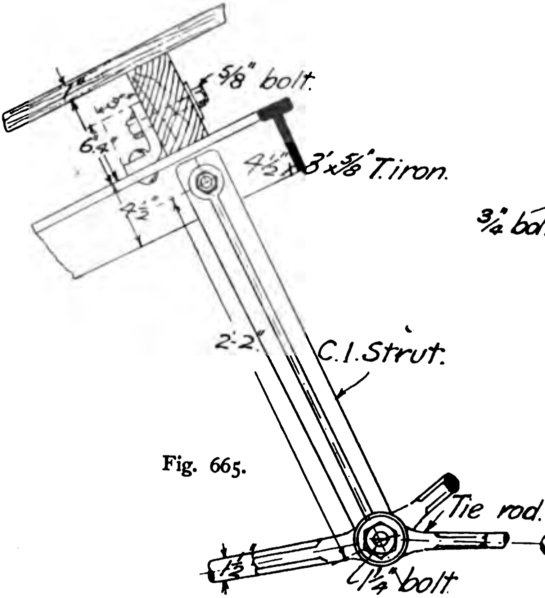


Fig. 665.

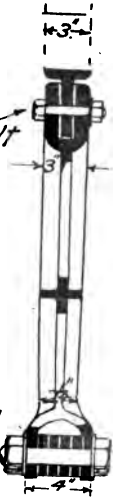


Fig. 666.

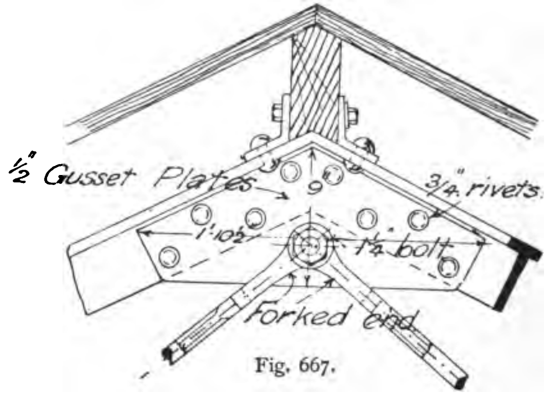


Fig. 667.

Figs. 665–667 Details of Joints.

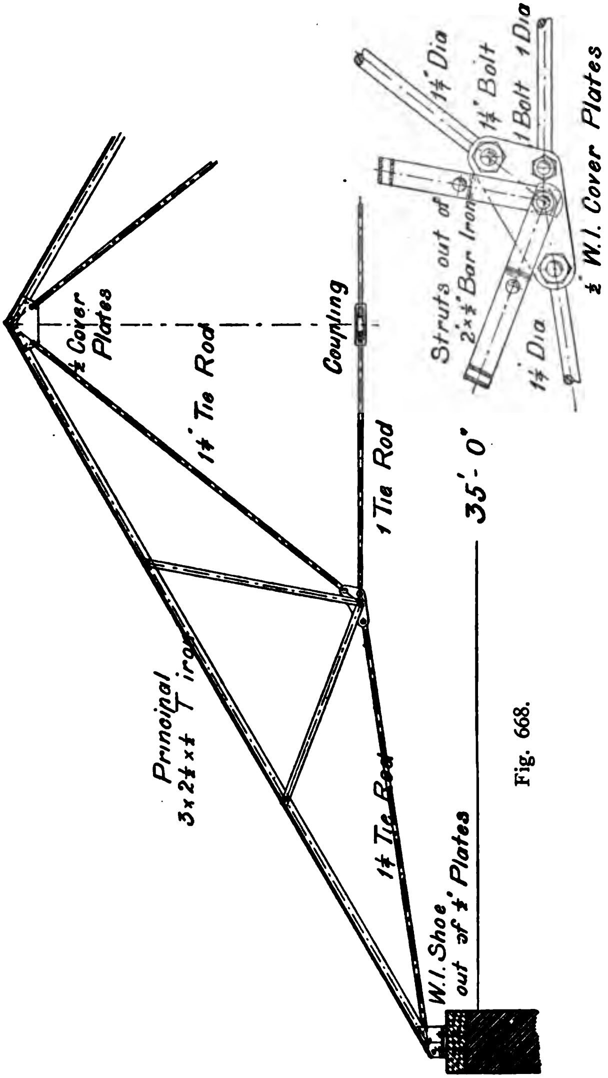


Fig. 668.

Fig. 669.

Figs 668, 669. Method of Arranging the Junction of the five Members of a Truss.

Pitch of Iron Roofs.—The pitch usually adopted for small roofs is ¼th, and for large ⅕th the span, but this is sometimes governed by the nature of the covering. Where an occasional leak is of little importance, the lesser pitch may be used.

Camber of Tie Rods.—Tie rods are usually cambered $\frac{1}{30}$ to $\frac{1}{40}$ the span, but in some cases more. This is done to reduce the length of the struts and to gain greater height above the floor level.

Tightening up Joints of Trusses.—Tension or tie rods are drawn tightly up or slackened by means of gibs and cotters, as in figures 688 and 689, or by adjustable screw couplings or union joints, as in figure 662. In the latter case the tension rod is in two pieces, the adjoining ends of which are thickened and screwed with right and left handed threads; the rotation of the coupling piece then draws the ends together or urges them farther apart.

Plus and Minus Threads.—Threads worked upon thickened ends of rods are known as plus threads, and those formed on rods without thickened ends are called minus threads, as the latter reduce the diameter of the solid rod.

Design of Joints.—Joints of trusses should be designed on the fork, eye, and pin principle. The centre lines of members should be drawn about each joint, all meeting in a point.

There are two general methods of construction:—1st. The interior member is constructed as an eye, as in figure 695, taking the common intersecting point as the centre, and the outer member or members forked, as in figure 700. A bolt, calculated as described in Part 2, is inserted, and acts as the common axis for all the members about the joint to rotate, as shown in figure 675.

2nd. All members are forged flat, and widened at extremities to one common thickness, or packed up to one common thickness, and eyes are drilled; two cover plates

Fig. 670.

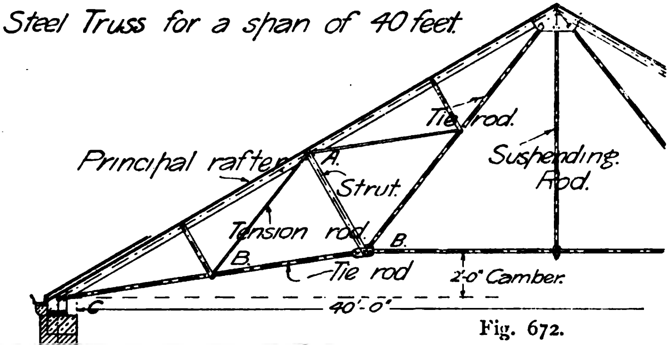


Fig. 672.

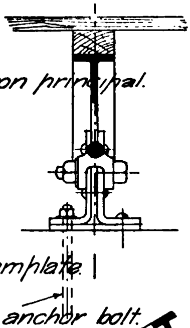
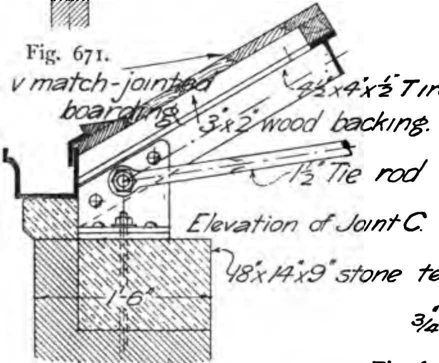


Fig. 671.



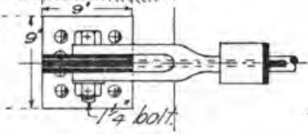
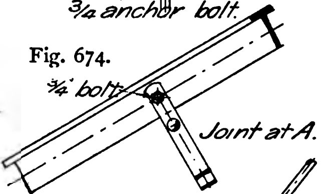
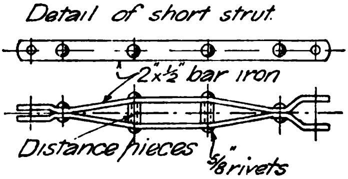


Fig. 673.

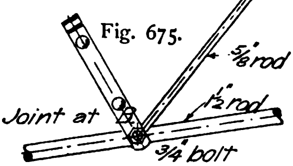
Fig. 674.





Figs. 677, 678.

Fig. 675.



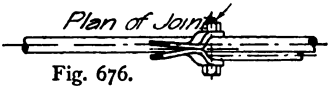
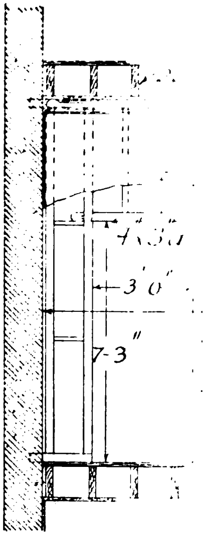


Fig. 676.

Figs, 670–678, Steel Truss for a Span of 40 feet.



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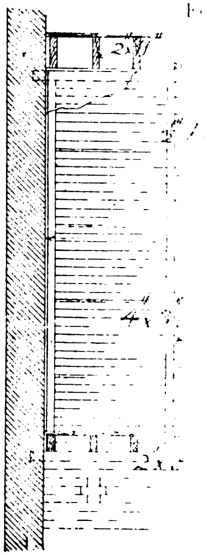


Fig

Iron Roof Truss for 50-ft. Span.

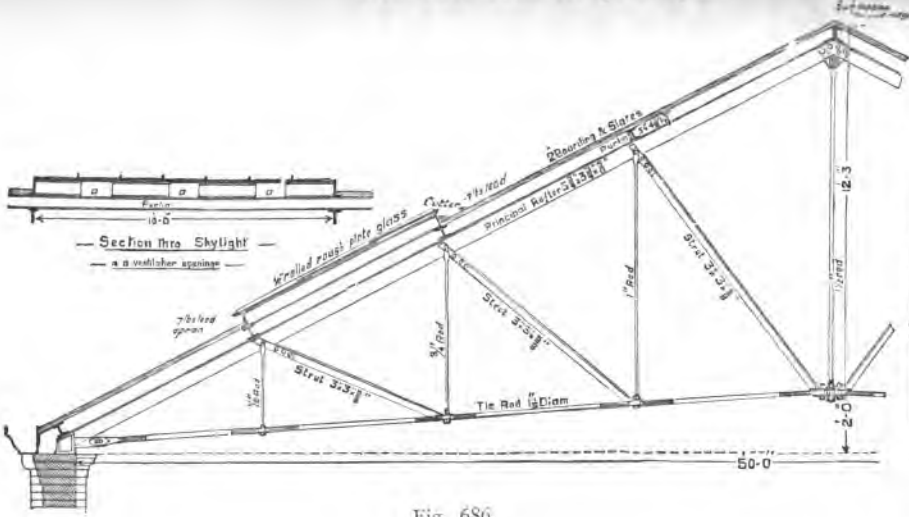


Fig. 686.

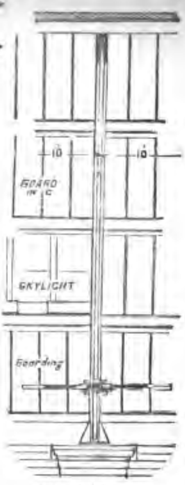


Fig 687.

enclose the whole of the members, having drilled holes coinciding with the eye holes of the members, the centres of which are in the centre lines at a distance sufficiently far from the common point of intersection to allow for the necessary width of metal about the eye hole, and a small clearance between the parts. Nutted bolts are then placed through cover plates and members. It may be noticed that a slight adjustment may cause the centre lines not to meet all in a common point, but

Fig. 679.

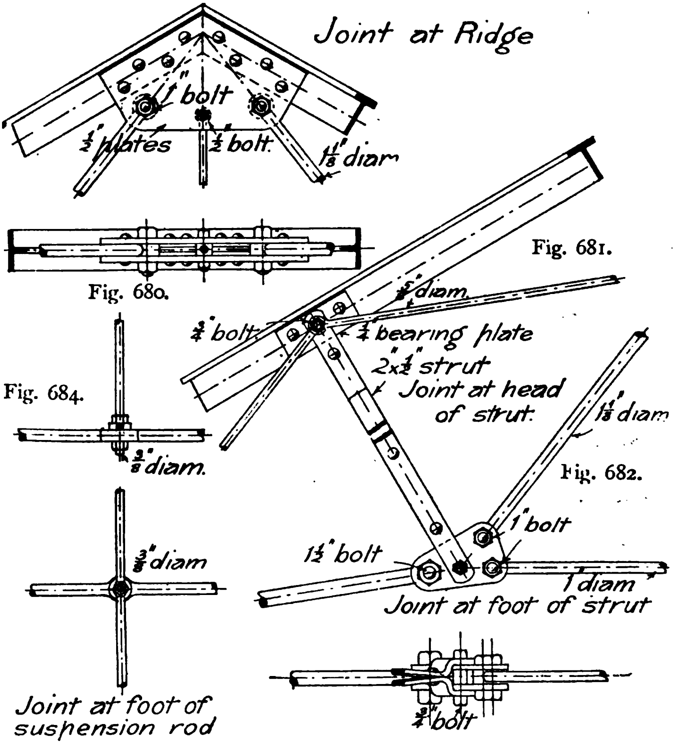


Fig. 680.

Fig. 681.

Fig. 682.

Fig. 684.

Fig. 685.

Fig. 683.

Iron Roof Truss for 50-ft. Span.

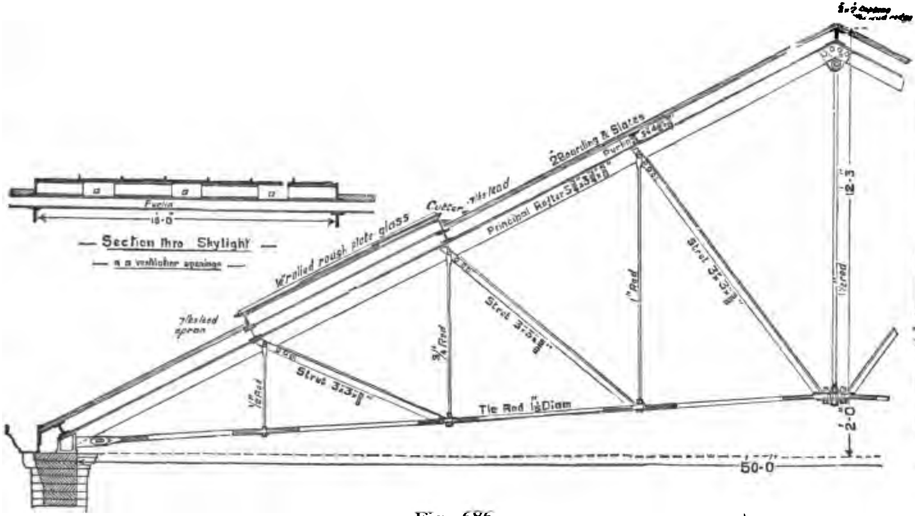


Fig. 686.

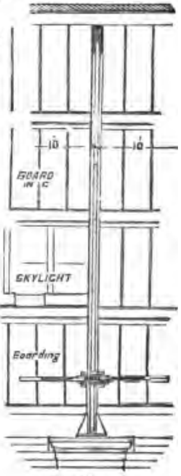


Fig. 687.

the error is usually so small that it may be neglected. The cover plates practically act as a common fork, and the enclosed struts and ties as a number of eyes, as shown in figure 650.

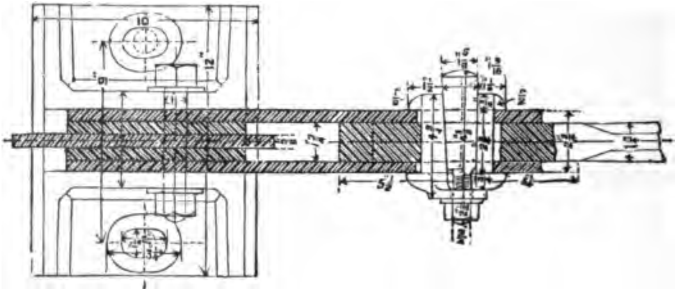


Fig. 688.

It may be noticed that various changes may be introduced thus, the cover plates may be designed to enclose a thin flat member, as the web of a principal rafter, and also to act as the

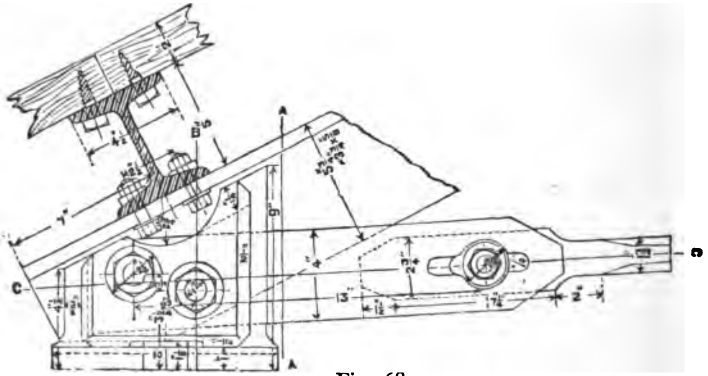


Fig. 689.

eye piece part to the adjoining member, which is forged as a fork, as shown in figure 699; but this is needlessly expensive.

Junction at Feet of Principal Rafters.—These may be constructed by riveting cover plates over web of principal rafter

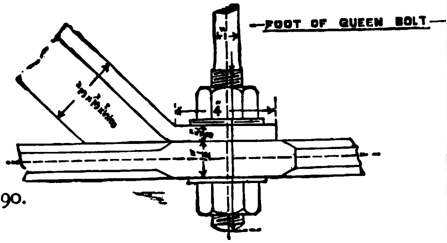


Fig. 690.

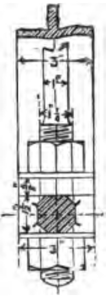


Fig. 691.

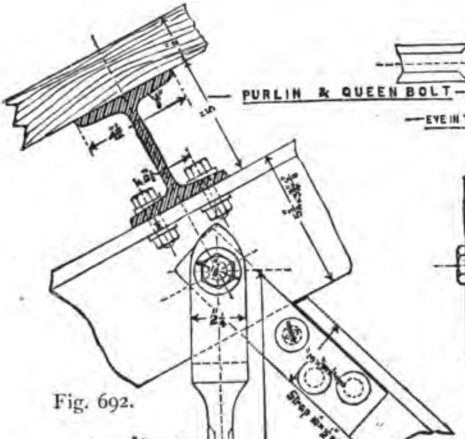


Fig. 692.

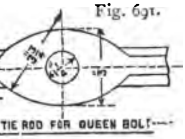


Fig. 693.

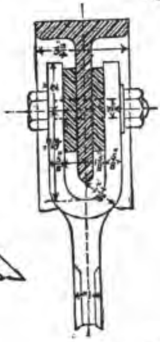


Fig. 694.

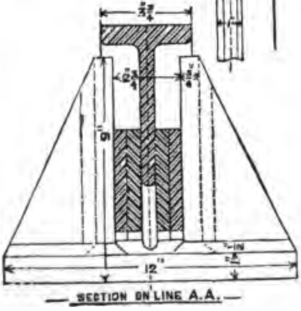


Fig. 695.

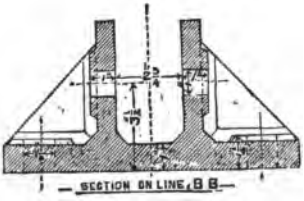


Fig. 696.

Figs. 690–696. Details of Iron Roofs.

Fig. 697.

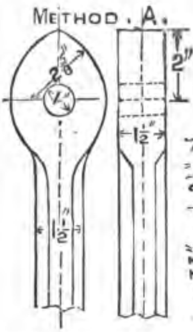


Fig. 698.

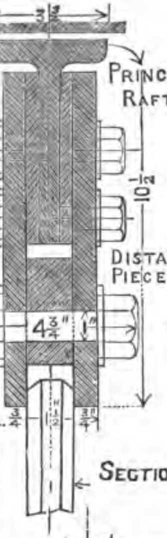
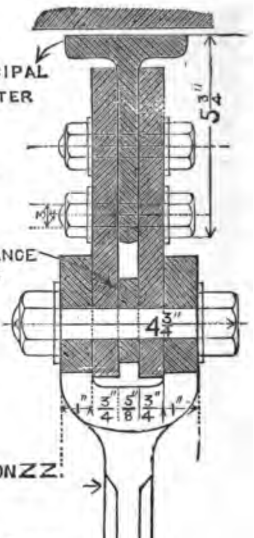
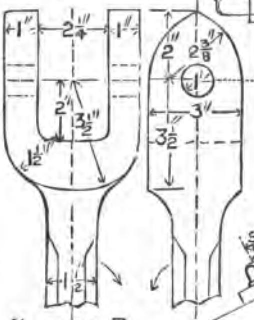


Fig. 699.





METHOD. B.
Fig. 700.

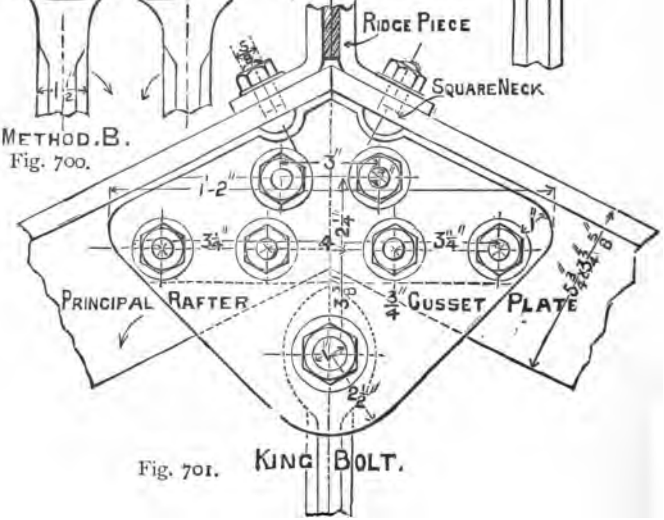


Fig. 701.

Figs. 697–701. Junction at Head.

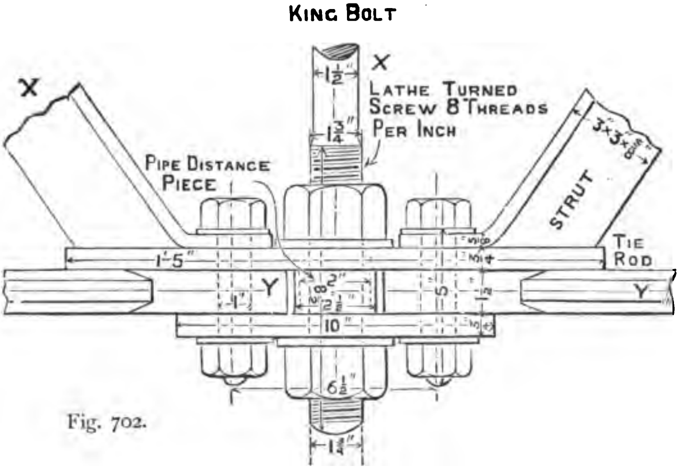


Fig. 702.

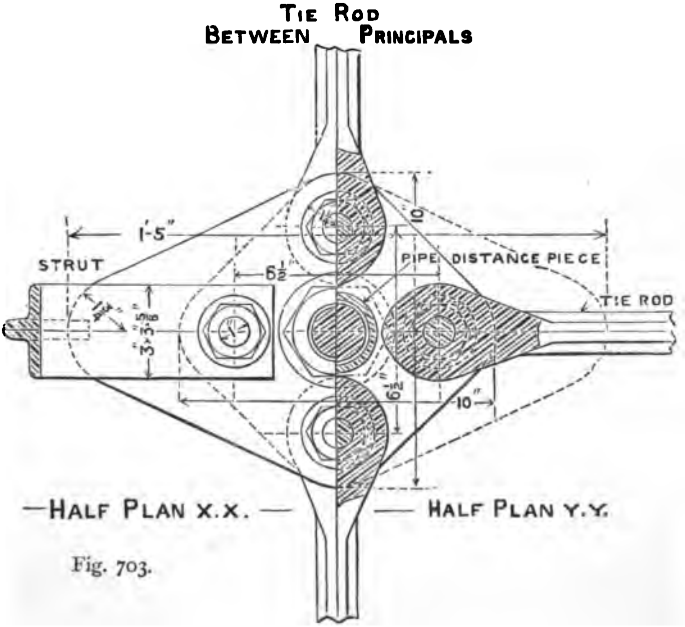


Fig. 703.

Figs. 702, 703. Junction at foot of King Bolt.

and flat tie rod, as shown in figure 644, by forking the tie rod over the web of the principal rafter and shoe, as in figure 663, or by arranging cover plates to fork over the web of the principal and bolting in both methods to cast-iron shoe, having side cheeks cast on, to prevent the principal moving laterally. The shoes are bolted on one side of the building to stone templates, and on the other by passing bolts through elliptical holes cast in the shoes, as in figures 688 and 689, to allow the truss, by being free, to move at one end in a horizontal direction to expand and contract under changes of temperature without hindrance.

Junction of Members at Foot of King Bolt.—These may be arranged, as shown in figure 644, by riveting to cover plates where all the members are of flat iron, or as in figures 702 and 703, which show king bolt, struts, and tie rods secured by nuts and bolts to junction plates. All trusses, to prevent them bulging laterally, should be tied together by rods at the feet of king bolts, as shown in figure 703.

Junction at Foot of Strut with Tension and Tie Rod.—This may be constructed with unequal forks to tie rod when in two pieces, the strut forked over both, and the whole bolted together, as in figure 658, or the horizontal portion of tie rods and lower jaw of tension rods may be forged slightly eccentric and eyes drilled, the strut and lower portion of the tie rod forked, and all bolted together, as shown in figure 661; or, as in the example of truss for 50-feet span, figures 702 and 703.

Junctions with two Struts and Tie Rod.—This joint often occurs in small trusses about 35-feet span, and may be constructed as in figures 668 and 669.

Junctions at Heads of Principal Rafters.—These may be formed by means of gusset plates—

(*a*) With tension rods forged flat at end, and eyes drilled, and thickness of web made out with packing pieces, and the whole riveted or bolted together according to its size, as shown in figure 698.

(*b*) By forking tension bolts over gusset plates packed out with pipe distance pieces, the length of which is equal to the thickness of the web of the principal rafter, and the whole is bolted or riveted together, as shown in figure 699.

Junction of Struts with Principals.—Where cast-iron struts are used, forks are cast on ends of struts for bolting to principal rafters and tie rods, as shown in figure 666; if flat bar or tee iron is employed for struts, straps are riveted to each side of the web of the struts to enclose web of principal rafter, to which it is riveted or bolted. If a tension rod is suspended from this joint it should be forked over, as shown in figures 692 and 694.

Dimensions of Members.—The following dimensions from actual practice are given in Molesworth's "Pocket Book":—

SCANTLINGS OF IRON ROOFS.—⅕ PITCH.

CAMBER OF TIE ROD $= \frac{\text{SPAN.}}{40}$ PRINCIPALS 6 feet 8 inches APART (see figure 643).

Span.	Principal Rafter.	Struts.	King and Queen Bolts. Diam. =			Tie Rod. Diam. =		
Feet.	Tee Iron.	Tee Iron.	*a.*	*b.*	*c.*	*d.*	*e.*	*f.*
20	2½×2×⅜	2×2×⅜	¾	⅝	—	⅝	¾	—
25	2¾×2½×⅜	2×2×⅜	⅞	¾	⅝	⅞	1	—
30	2¾×2½×½	2½×2½×⅜	1	¾	⅝	1	1⅛	—
35	3×2¾×½	2½×2½×⅜	1	¾	¾	1	1⅛	1¼
40	3½×3×½	2½×2½×⅝	1⅛	⅞	¾	1⅛	1¼	1⅜
45	4×3½×½	3×3×½	1¼	1	⅞	1¼	1¼	1⅜
50	4×3½×⅝	3×3×⅝	1¼	1	⅞	1¼	1⅜	1½
55	5×4½×⅝	4×4×½	1⅜	1⅛	1	1⅜	1½	1⅝
60	5×4½×¾	4×4×⅝	1⅜	1⅛	1	1½	1⅝	1¾

¼ Pitch.—Camber of Tie Rod = $\frac{\text{Span}}{30}$ (see fig. 640).

Span.	Principal Rafter—Tee Iron.	*h.*	*j.*	*k.*
20	2½ × 2 × ⅜	⅝	⅞	⅝
25	2¾ × 2 × ⅜	¾	1	¾
30	2¾ × 2½ × ½	2¼ × ¼	2¼ × ⅜	2¼ × ¼
35	3 × 2¾ × ½	2½ × 5⁄16	2½ × ½	2½ × 5⁄16
40	3½ × 3 × ½	2½ × ⅜	2½ × ⅝	2½ × ⅜
45	4 × 3½ × ½	3 × ⅜	3 × ½	3 × ⅜

Small Trusses.—Trusses up to 20-feet span are usually made without struts, simply tee iron principal rafters and flat or round iron for tie and king bolts, or with corrugated iron overlapping, and riveted together in the form of an arch, and prevented from springing by the tie forming the chord of the arch.

Elevation of Trusses.—Up to 30-feet span, trusses may be formed by T-iron principals, and flat bar for tensional members, the joints being held together by riveting to cover plates.

Figures 660 to 667 show a method of forming trusses suitable for spans of 30 feet, using round bar iron for tensional members, T-iron for principals, and cast iron of cross section for struts.

Figures 652 to 659 give all necessary details and methods of securing shoes to cast-iron stanchions or to stone templates, and method of forming ventilators at apex. The truss for 30- to 40-feet spans is sometimes economically arranged by using two cast-iron struts, which are supported at the junction of tension and tie rods, and in their turn uphold the principal rafter. Figures 668 and 669 show method of arranging the junction of the five members.

40 feet to 50-feet spans may be roofed, as illustrated in figures 670 to 685, which is known as the Belgian truss, or, as in figures 686 to 703, which illustrate an English truss, with method of constructing skylight, and obtaining ventilation.

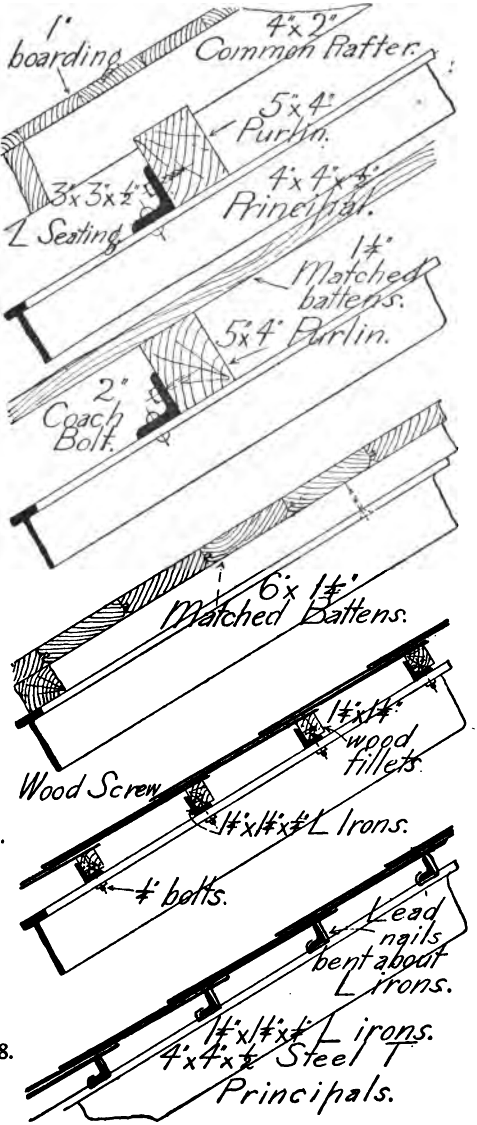


Fig. 704.

Fig. 705.

Fig. 706.

Fig. 707.

Fig. 708.

Figs. 704–708. Fixings for Coverings.

Coverings of Iron Roofs.—Corrugated iron, as in figure 646, is especially suitable for places where it is desirable to collect the rain water. Slates, zinc, and glass, as illustrated in figures 707 and 659, are usually the coverings employed for iron roofs.

Fixings for Coverings.—There are five general methods for preparing the ground for fixing the roof coverings. 1st. Wood purlins resting against and being bolted to an angle iron cleat, as shown in figure 704, with common rafters and boarding in the usual manner. 2nd. Purlins fixed at more frequent intervals than in the preceding case, and stout boarding fixed directly thereto, as shown in figure 705. 3rd. The principals are backed with timber 2 inches in thickness for their whole length, the iron principal being drilled at intervals of 2 feet for the wood screws to secure the backing, and on this, stout boarding, the thickness of which varies with the distance between the principals, is fixed, as shown in figure 706. 4th. Small angle irons are bolted to principals at intervals equal to the gauge of the slate used, to the small angle irons, wood fillets 1¼ by 1¼ are fixed, to these the slates are nailed. This dispenses with the use of roof boarding, as shown in figure 707. 5th. Occasionally, in order to dispense with timber, small **L**-irons are fixed as before, the slating being secured to the same by long lead nails which are bent about the **L**-iron, as shown in figure 708.

CHAPTER XI.

JOINERY.

Definition.—Joinery is the art of preparing and framing pieces of timber together to form the finishings of houses, and comprises all wood-work fixed for decorative purposes, as well as for convenience or utility, apart from structural work.

Design of Joinery.—Joinery is not required to resist great stresses as in the case of carpentry works, appearance, not strength, being the primary consideration; all the skill of the joiner is therefore expended in constructing the work in such a manner that it shall resist deterioration.

There are three ways in which joinery becomes defective. First, by the warping or splitting of the material; secondly, by the joints coming apart owing to the expansion and contraction of the material; and, thirdly, by the decay of the material.

The following conditions should therefore be strictly adhered to in designing and constructing joinery:—

1st. Frame all parts in such manner as to allow for shrinkage or free expansion, at the same time making them of a thickness sufficient to prevent warping, this being best determined by experience.

2nd. In order to render the amount of shrinkage inappreciable, members should be made as narrow as possible.

3rd. All stuff should be thoroughly seasoned and chosen from the heart wood of a tree, all sapwood being rejected

All the exposed surfaces are usually prepared to take a covering of paint or polish for decorative purposes, or to preserve them from the effects of the atmosphere. The wood employed is called stuff, and comprises battens from 2 to 7 inches in width and ¾ to 3 inches thick, boards 7 to 9 inches wide and 2 to 4½ inches thick, and planks any width above.

The operations of joinery include sawing, planing, shooting, chamfering, rebating, grooving, scribing, moulding, mitreing, and the construction of joints and frames in such a manner as will allow the wood to shrink and swell without hindrance.

Sawing.—The cutting of wood by means of saws. On machines these would be rack, band or circular, but for hand use may be rip, hand, tenon, dovetail, key and fret saws.

Planing.—The taking shavings off wood by means of planes and is described as dressed, wrought, which, when brought to a level surface, is said to be out of winding

Shooting.—The planing of the edges of boards straight and square with face.

Chamfering.—Taking the arrises or edges off boards; forming a bevel, generally by means of a plane. When two chamfered edges are placed together, as in figure 727, it makes what is known as a **V**-joint.

Rebating.—The planing or cutting away of a rectangular section from the edge of the board.

Plough Grooving.—Grooves made parallel to edges of boards, with a special tool termed a plough.

Cross Grooving.—The operation of forming a sinking across the grain, and is often done with a saw and router, as in the case of housings for risers and treads into strings, or a groove is sunk entirely across a board by a special plane with cutting teeth, called a grooving plane.

Tongues or Feathers.—Thin pieces of wood, usually pine veneer, cut $\frac{7}{8}$ inch wide, about $\frac{1}{8}$ to $\frac{1}{4}$ inch thick, inserted in plough grooves, to prevent dust, light or air passing through the joint of battens or boards, should the latter shrink. If cut with the grain they are called straight tongues or feathers. When cut across the grain, they are known as cross tongues or feathers. The latter are used where considerable shearing stress is to be resisted, as the former under such conditions would split.

Moulding.—A piece of stuff is said to be moulded when it is worked on its face into a series of curves and bands; mouldings may be worked either by hand or machine. In the former case, they are stuck by means of hollows and rounds, which are narrow planes, the cutting faces of which are the reverse of the varying curves to be worked.

The section is usually marked on the ends of the piece of stuff by means of a zinc templet cut to the section of the moulding. Where mouldings are produced on a large scale they are usually worked by machinery.

Mitreing.—This is the process usually applied to the junction between two pieces of stuff that are jointed at an angle one with the other. If the two pieces to be joined are of an equal width, the mitre cut bisects the angle.

Scribing.—The process of fitting skirtings, linings or framings to irregular surfaces, also of cutting one moulding to fit a similar moulding in an internal angle instead of mitreing.

Framing.—Large areas requiring to be covered with woodwork should comply with the conditions stated on page 253.

A frame is usually constructed by joining together narrow pieces of stuff, in width about 3″, with a mortice and tenon joint, as shown in figures 770 to 773. The pieces enclose a number of rectangular or other shaped spaces, and usually have grooves on their inside edges into which the edges of pieces of stuff termed panels are fitted. The framing completely encloses the panel, preventing it from twisting, but allowing it to expand and contract freely. The great bulk of the area should be taken up by the panels, only a relatively small portion being taken up by the framing.

The vertical members, forming part of the boundary of the frame, that are mortised are termed styles, all other vertical members between the styles are termed muntins, and the horizontal members are termed rails.

Method of Glueing up Framing.—When all the members have been prepared and fitted, the framing is laid upon bearers (the upper surfaces of which are fixed "out of winding"), and all the tenons and shoulders are coated with hot glue; the frame is then pulled up with an iron cramp; it is then secured by wedges, dowel pins, or wedges and dowel pins combined, which have been dipped in hot glue. In frames for exterior work white lead is used instead of glue, and dowels are often employed, especially where mortices or slots are cut with a saw, as in figure 755.

Panelling and Moulding.—Specifications of framing should include the method in which the panels are treated, and the manner and extent of the moulding of the frame.

The panels may be either flat, raised, raised and moulded, bead flush, bead and butt or flush only. The framing may be square or moulded.

There are three methods of moulding frames: first, by planting; secondly, by working the moulding on the frame; thirdly, by framing the mouldings, and grooving them into the frame.

Figure 711 shows a section of square framing and flat panel, with a planted moulding. Figure 712 shows a section with the moulding stuck on the solid, and a raised panel. Figure 713 shows a framed bolection moulding with a bevelled raised and moulded panel. The object of bevelling is to add strength to the panel by having the latter of greater thickness than the circumscribing groove. Care must be taken to make

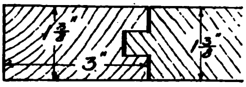


Fig. 709.

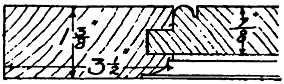


Fig. 710.

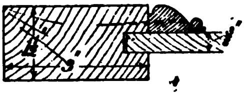


Fig. 711.

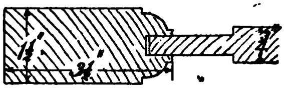


Fig. 712.

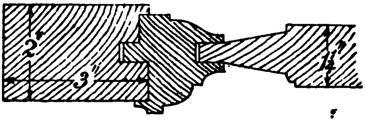


Fig. 713.

the thickness of the panel that enters the framed bolection moulding parallel, otherwise, if any shrinkage takes place, the panel becomes loose if the bevelling be continued to the edge of the panel. In order to gain strength the panels are often made flush with the framing, as shown in figures 709 and 710.

The method of planting mouldings is bad, and should never be used for good work; but where adopted, care should be taken that the mouldings are nailed to the frame and not to the panel.

Small mouldings are best stuck on the solid. These mouldings should be scribed together at the angles where the section and position render it possible, otherwise they are mitred.

Mouldings exceeding 1 inch in width should be framed. The framed mouldings are usually mitred, tongued, glued, and screwed at angles.

Mouldings are often continued from the sides of a frame, and planted on the face of the panels to various designs; under these conditions great care must be taken to fix the mouldings so that the grain of the moulding is in the same direction as the grain of the panels; this will necessitate a large amount of the moulding being stuck across the grain. If this be not done, those mouldings that are fixed with their grain at right angles to that of the panels will after a short time become detached, owing to their inability to expand or contract with the panel; they also have the tendency to split the panel.

Flush Panels.—Panels are often prepared flush with the framing on one or both sides in order to obtain increased strength. A bead is usually stuck on the edges of the flush side that are in the direction of the grain to save the appearance of the large open joint that occurs when the panel shrinks; the transverse edges are left square, as the panel does not shrink in the direction of its length. Such panels are termed bead butt. Flush panels of the above description often have the bead carried round the four edges of the panel; this is bad as carried out in ordinary practice, the transverse bead being let into the panel, and having its grain at right angles to same, thus preventing its shrinking freely, the panel being frequently split. If beads are required on the four sides, they should be stuck on the frame. Panels are often made flush both sides, being ornamented with beads or mouldings on both sides, or left plain; the latter usually being done where it is required to cover the same with baize or other material.

Mouldings.—Most of the groups of mouldings used by the joiner consist of combinations of some of the Greek or of the eight Roman examples. Invariably the Roman mouldings are found to have their prototype in the Grecian examples, the chief difference being, that the Greek are either segments of some of the conic curves or are struck freehand, while the Roman curves are all segments of circles.

(1.) *Fillet.*—This is a narrow flat projection often used to divide individual or groups of mouldings in any composition; it is similar in both Greek and Roman work, as shown in figure 718.

(2.) *Astragal* is a small semicircular moulding, as shown in figure 719, often used in combinations of mouldings, but chiefly to

Fig. 714.

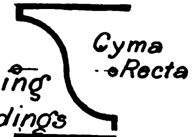


Fig. 715.

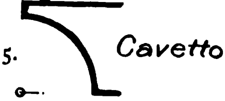


Fig. 716.

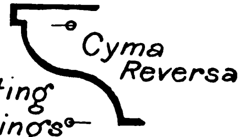


Fig. 717.

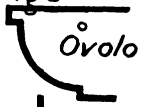


Fig. 718.

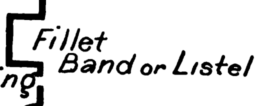


Fig. 719.

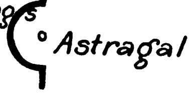


Fig. 720.

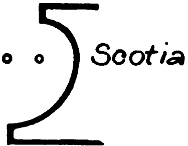


Fig. 721.

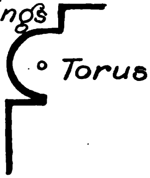
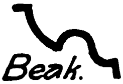


Fig. 722.



mark the division between the shafts and caps of columns. It is also largely used in the joints of straight members in joinery that are not glued, such as the joints of match-boarding or the meeting styles of doors, sashes, etc., so that if the wood shrinks the shadow cast by the moulding will detract from the unsightliness of the joint. This member is similar in Greek and Roman.

(3.) *Cavetto.*—The cavetto is a hollow moulding, as shown in figure 715, consisting in the Greek of a quarter of an ellipse and in the Roman of a quadrant.

(4.) *Ovolo.*—This moulding in the Greek consists of a segment of an inclined ellipse, having a fillet at the top and bottom, and forming at the top a quirk. In Roman work, as shown in figure 717, it is a quarter circle, rounded at top and bottom by a fillet.

(5.) *Cyma Recta.*—This is a double curve, formed in the Greek of two quarter ellipses whose minor axes are in the same straight line and bounded top and bottom by a fillet. The Roman example, as shown in figure 714, is similar, but consisting of two quarter circles. This moulding has a concave portion of its surface above the convex, and is generally used as a crowning member.

(6.) *Cyma Reversa.*—As its name implies, is the reverse of the preceding moulding, slightly modified in the Greek by having a quirk above, between the same and the fillet, and the hollow portion slightly more concave. The Roman is an exact reverse, as shown in figure 716.

(7.) *Scotia.*—The scotia in the case of the Greek is formed of an inclined ellipse, having a fillet above and below. The Roman is struck from two centres on a common radial line, as shown in figure 720.

(8.) *Torus.*—The torus is a base moulding, the Greek form being the reverse of the scotia. Many Greek examples are, however, similar to the Roman, consisting simply of a large semicircle with a quirk below and a fillet above, as shown in figure 721.

(9.) *Bird's Beak.*—This moulding only occurs in the Greek mouldings; it consists of a quarter ellipse (with the major axis horizontal), in the lower side of which a small hollow has been worked, as shown in figure 722, and is used as a supporting moulding.

In the designing of groups of mouldings for cornices, strings etc., reference should be made as to the suitability of the mouldings for their intended position, and for this purpose they may be divided into base mouldings, connecting mouldings, supporting mouldings, and crowning mouldings. The base mouldings would include such mouldings as the torus, the scotia or the inverted cyma recta, and any combination of such mouldings that would tend to broaden the base and distribute the weight of the mass supported.

Connecting.—These include the fillet and the astragal.

Supporting.—The supporting mouldings include such members as the ovolo, bird's beak and the cyma reversa, mouldings that do not have their hollow members near their upper edge, and such as have their mass in a position to strengthen the same, and are fitted to act as corbels. These mouldings are used to form the bed mouldings or lower parts of combinations, such as cornices which are divided into two parts, the bed mouldings and the crowning mouldings.

Crowning Mouldings are those mouldings which are not expected to carry anything above, such as the cyma recta and the cavetto, the top members of which are small and delicate.

The above ideas are not always rigidly adhered to, and successful departures from the same are often made with good effect; but it is prudent to bear these principles in mind when designing any groups, as if too widely departed from confusion ensues.

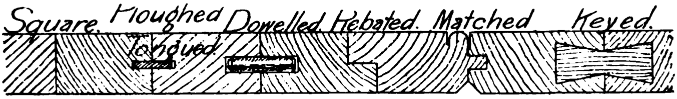
Joints.—Joints in joinery are classified as follows:—1. Side joints; 2. Angle joints; 3. Cross joints; 4. Joints to prevent warping; 5. Framing joints.

(1.) *Side Joints.*—The side joints that have been used in connection with floors have been explained and illustrated in the chapter on that subject. The remainder are as follows:—The plain or square joint: in this case the edges are shot true, so that if a straight edge be applied to their common face when the boards are applied one to the other, it shall be in an approximate plane: it is necessary to try the boards in this way, and not attempt to shoot the edges square, as the boards generally cast and twist a certain amount in their rough state. When the joint is prepared the two edges are applied together and are glued; this accomplished, the edges are placed in position and the top board rubbed backward and forward on the bottom to rub all the superfluous glue out of the same and to cause a certain amount of suction. When the joint is adjusted it is left till it is dry, and then cleaned off and prepared for the purpose for which it is intended.

While the joint is in a wet condition the pieces are often secured by cramps or cleats, to prevent any movement in same till dry. All kinds of glued joints between boards should be treated in this way. Figure 723 shows a plain or square joint.

The Tongued Joint. — In this method, as shown in figure 724, the edges are shot as before, a groove is made in the centre of each of same $\frac{1}{8}''$ by $\frac{1}{2}''$ in depth at the most by means of a plough. Cross tongues 1″ in width are then inserted in one of the grooves, the joint is then tried, glued, and rubbed as before. Increased strength is obtained in the joint by this method, as a larger glued surface is obtained and the two pieces are to a certain extent interwoven. It is not good, however, for panels of $\frac{1}{2}''$ thickness or under.

Figs. 723. 724. 725. 726. 727. 728.



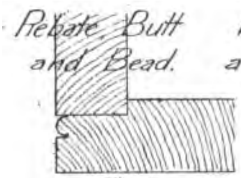


Fig. 729.

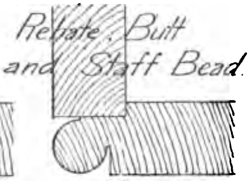


Fig. 730.

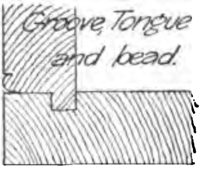


Fig 731.

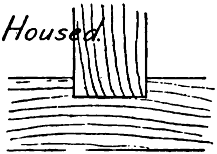
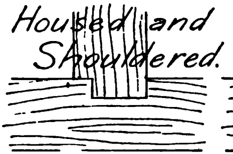


Fig. 732.



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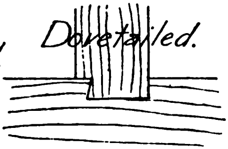


Fig. 734.

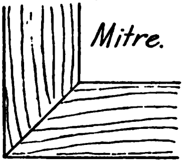


Fig. 735.

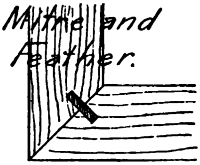


Fig. 736.

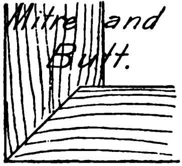


Fig. 737.

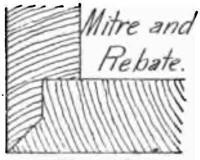


Fig. 738.

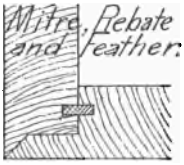


Fig. 739.

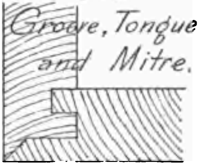


Fig. 740.

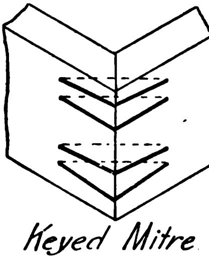


Fig. 741.

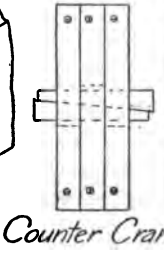


Fig. 742.

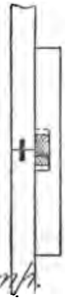


Fig. 743.

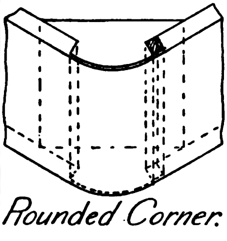


Fig. 744.

The Dowelled Joint.—The edges in this joint shown in figure 725 are shot in the ordinary manner, the boards are then placed face to face with the shot edges uppermost; they are squared across about every 18″, a gauge mark is scratched about the centre of the edges from the face of each board (thus obtaining the exact centre for each dowel), the holes are then bored about ¾″ deep, the dowel inserted, the edges glued, and the boards cramped up. This makes a very strong joint.

Keyed Joint.—This joint, as shown in figure 728, is not much used at the present except in imitation of old work. It consists of a dovetail shaped key, about 3″ in length, let into the ends and the back of the boards to be joined, and cleaned off level with the back of the same.

There are several side joints in which the pieces are not intended to be glued together, such as the following:—

The Matched Joint.—The form of the joint, as shown in figure 727, is a grooved and tongued arrangement, having on the tongued edge a moulding, generally a chamfer or a bead, to emphasize the joint, and so obliterate the ill effects of the open joints that ensue on shrinkage. Matchboards are employed in the place of framing where large surfaces are to be covered. They should not be more than 4″ in width, and should be nailed on one edge only, in order that no joint shall open too much, and that the whole shall be free to shrink. A similar joint to this is used for the joint of horizontal sliding sashes where it is desired to obtain a dust and draught-proof joint.

The Rebated Joint.—This is generally employed for the meeting styles of folding-doors and sashes for mutual support, and to prevent an unobstructed through joint, see figure 726.

(2.) *Angle Joints.*—These joints are divided into three classes—(*a.*) Those in which the joint is parallel to the grain of the pieces joined. (*b.*) Those in which the joint is at right angles to the pieces joined. (*c.*) Those which may be used in both of the above cases.

(*a.*) *Rebate, Butt, and Staff Bead.*—In this, as shown in figure 730, there is a rebate formed, so that the pieces may be easily placed in position, a staff bead being worked at the angle to ornament same. The two pieces are secured by nailing, or by glueing and blocking.

Rebate Butt and Bead.—This is worked similarly to the preceding example, having a small bead at the side instead of a large angle bead; this is shown in figure 729. It is used where one face is required perfectly plain.

Groove Tongue and Bead.—This member has a tongue instead of a rebate, as shown in figure 731. These three forms are usually employed where the work is fixed piece by piece, it being difficult to obtain a close joint; the moulding is added to counteract this defect. If the angle is glued, some form of a mitred joint is generally employed.

(*b.*) *Joints across the Grain.*—The principal joints for this purpose are, 1, the common dovetail; 2, the lap dovetail; 3, the secret dovetail, the first being used if the visible joint be of no account, the second where it is desirable to have one face perfectly clear, and the third if both faces are to be seen. They are made as shown in figures 745 to 747.

The Keyed Mitre.—The pieces are here mitred, placed into position, and a number of pairs of saw cuts inclined to each other made across the angle. The joint is then glued, put together, and into the cuts are fitted coarse shavings, which are glued and fitted tightly, as shown in figure 741.

(*c.*) *Joint common to both directions of Grain.*—These resolve themselves into some form of the mitre joint; the common mitre, as shown in figure 735, is easily formed but difficult to fix together, and is unreliable unless glued and blocked for its whole length.

The Mitre and Tongue.—This is a good and strong joint, but the grooves are difficult to form unless a machine is used.

The Mitre and Butt.—This joint, as shown in figure 737, is used where the pieces are of unequal thickness.

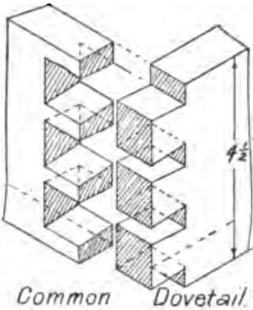


Fig. 745.

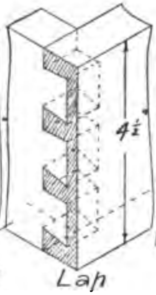


Fig. 746.

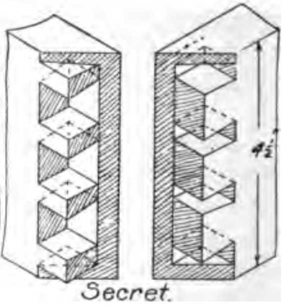


Fig. 747.

The Mitre and Rebate.—This joint, as shown in figure 738, is more difficult to prepare, but is a very good form for jointing, especially where nails only are employed.

Mitre, Rebate, Butt and Tongue.—This joint, as shown in figure 739, is used where the joint is parallel to the pieces joined; it is used in the best work, for the angles of pilasters, etc. It is glued and blocked, if possible no nails being used.

(3.) *Cross Joints.*—Cross joints are of two forms—(*d.*) Those in which the edge of one piece is fitted into the side of the other; (*e.*) those in which the pieces completely cross.

(*d.*) *The Housed Joint*, as shown in figure 732, is used where the pieces are gauged to a thickness, and it is possible easily to fit the one exactly into the other, the two pieces being secured by nailing.

The Shoulder and Housed.—This is used either where the housed member is rough on one side—a tongue is therefore worked as being the most expeditious method of fitting—or where the internal angle is to be seen. In this case the shouldered joint gives the cleaner appearance. This joint is shown in figure 733.

The Dovetailed Housing.—This is employed where it would be undesirable to fix the pieces by nailing, and is shown in figure 734.

(*e.*) The second class of cross joints is used in constructing the carcases for drawers, or for nests of shelves, etc.

In many instances the uprights are usually solid, and the horizontal rails are about 3" wide. The joint is a combination of the halved and housed joint; the idea is to have both members continuous and so increase the tie. The same arrangement is used for positions in which the members are of an equal width.

Counter Cramp.—Figures 742 and 743 show a counter cramp which is a convenient arrangement for drawing up the heading joints of wide surfaces such as counter tops.

Rounded Corner.—Figure 744 shows a method of constructing a rounded corner showing continuous grain. It consists of a solid block cut to the shape of the curve about which the stuff to be bent, after having been reduced to $\frac{1}{8}$" in thickness, is bent, glued, wedged, and screwed.

(4.) *Joints to Prevent Warping in Wide Surfaces.*—All boards have a tendency to warp or cast if left to themselves or with insufficient fixing, and when several are jointed for such purposes as table-tops, fascias, dados, or sign-boards, the defect is liable to be greater. To reduce the amount of the casting to a minimum, the boards should be selected and matched with the heart side of adjacent boards on opposite faces of the work, and means must be taken to fix the boards in a flat position, but in a manner that they will be able to shrink and expand freely. There are four general methods employed for this:—1, the dovetailed key; 2, the batten and slot screw; 3, the batten and button; 4, by iron rods.

Fig. 748.

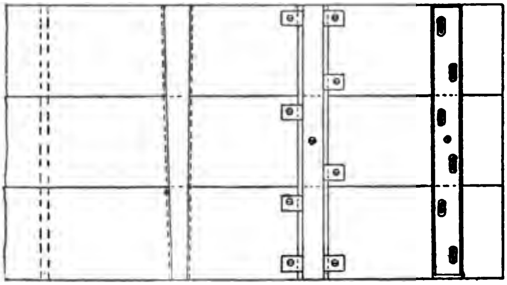
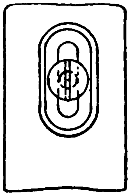


Fig. 750.



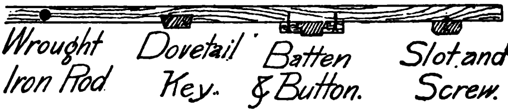


Fig. 749.

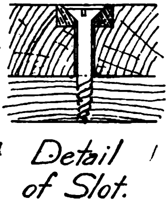


Fig. 751.

In the first method, as shown in figure 748, a wood key of the shape shown in figure, dovetailed on its edges, is fitted to a cross groove made to receive it. The object of tapering the key is to render it easier to fit. After the key is driven in, it is screwed at its wider end.

The Slot Screw and Batten.—By this method a batten of sufficient thickness is prepared with a number of countersunk slots, into which brass slots are fitted; these are placed on the back of the boarding, one screw is driven in the ordinary way through the centre of the batten to fix the latter to the work, screws are driven into the centre of each slot; the latter fix the batten and boarding together, but allows the work freedom to expand or contract, see figure 748.

The Batten and Button.—This method is more effective than the last, but is unsightly. It consists of a rebated batten screwed to board in centre, and secured by hardwood buttons of the form shown in figure 748.

The Iron Bar.—In this case holes are bored through the edges of the boards before they are glued up. The iron bar is next passed through the holes in the edges, which latter are glued, and the joints are closed by means of cramps. This method, as shown in figure 748, is very effectual, especially if both sides of the work are exposed to view, or where there is no room for any projections at back.

(5.) *Framed Joints.*—These joints invariably resolve themselves into some form of the mortice and tenon joint.

The form of the mortice and tenon joint is shown in figure 770. The typical dimensions for such a joint are as follows:—The thickness of tenon should be ⅓rd of the thickness of the stuff, and the width should not exceed four times the thickness, and in no case more than 2″ in width. The reason for the latter rule is that if the tenon is of a greater width than that stated, it has a tendency to bend under the pressure of the wedges, and in the second place it is necessary to keep the tenon sufficiently narrow to render the shrinkage in same inappreciable.

Haunchion.—Consists of a stump tenon, usually ½in. long, adjoining the tenon proper, fitting into a groove cut to receive it, as in figure 770, to prevent the tenoned piece twisting, also to obviate a through joint, and to keep the surfaces of the rails and styles in the same plane should the joint shrink or become loose. The shortness of the haunchion adds great strength to the root of the tenon, about which, but for the haunchion, it would often snap when exposed to sudden shocks. The roots of tenons in thick stuff are sometimes also assisted to resist stress by cross tongues, as in figure 752.

The wedges employed should be thick at the narrow end, and have a very slight inclination, in order that when they are driven home they shall compress the tenon with the greatest force at the root, so that should any shrinkage take place in the style, its direction would be towards the shoulder.

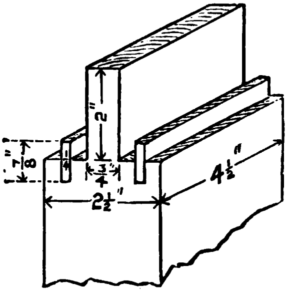


Fig. 752.

Double Tenon.—Figure 772 shows a double tenon, which is used if the framing is very thick, or as in this case at that end of rail where it is intended to fix a mortice-lock into the style; the minimum distance between the tenons should be the thickness of the lock. The rule respecting the thickness of double tenons is that the sum of the double thicknesses should equal ⅓rd the thickness of the stuff. On the other end of the lock rail a double pair of tenons is unnecessary.

Joint at Lock Rail of Diminished Style.—This joint, as shown in figure 783, is similar in principle to that of the ordinary lock rail, the difference being that it is moulded at the top, and has a bevelled joint.

Bottom Rail.—Where the bottom rail is wide, as shown in figure 773, there are two tenons which are set out differently from the middle rail, owing to the end of style and bottom edge of rail being flush.

Foxtail Wedging.—Figure 774 illustrates the method of fixing known as foxtail wedging. The mortice in this case is stopped about $\frac{1}{2}''$ from the back edge of style, and is cut slightly dovetail in shape. The tenon has a saw cut about $\frac{1}{8}''$ from each side, into which a wedge is inserted, and on being cramped up the wedges are forced home. There should be a space allowed of the thickness of the wedge in the mortice at the end of the tenon, otherwise in the event of a wedge being turned over, it would prevent the joint closing, and it would be a matter of great difficulty to withdraw the same. This joint is employed in the best work, where it is undesirable to see the end grain of the tenons penetrating the styles.

The joints at the angles of moulded sashes are similar in principle to the above, but modified, as shown in figure 754, to meet the different conditions.

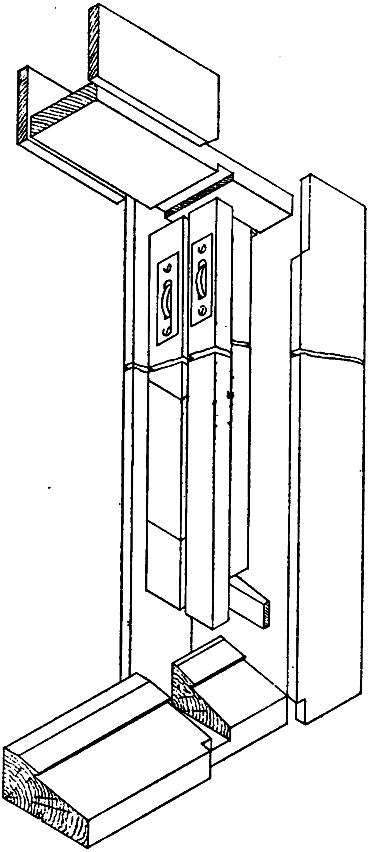


Fig. 753.

Joints employed in Double Hung Sash Frame.—Figure 753 indicates the method of constructing the joint between the side and sill, and the side and head of the above-mentioned frame. The sill and head are housed as indicated. The pulley lining is wedged and nailed to sill. The head is nailed to pulley lining only; the end of the head is slotted to receive parting slip. The frame in this condition is squared, and the linings are nailed on to each side of the frame. The back linings are fixed and the head

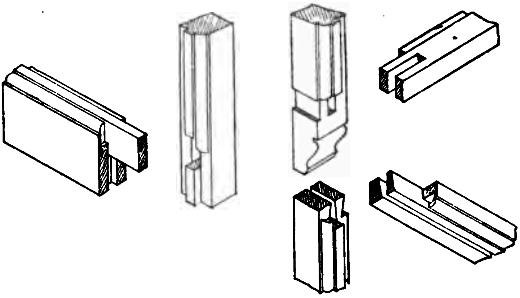


Fig. 754.

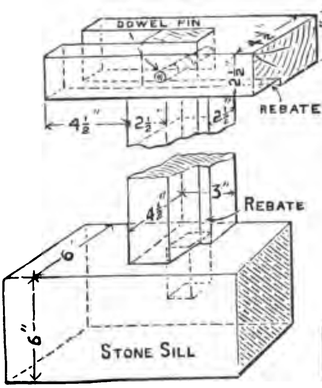


Fig. 755.

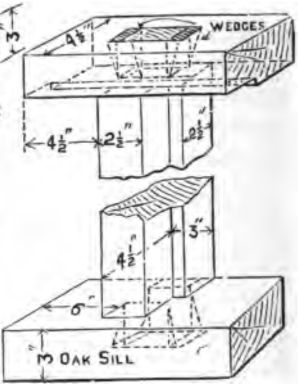


Fig. 756.

linings are blocked, and when the beads are fixed, the frame is complete, as shown in figures 789 to 791.

Solid Frames.—These are used for doors and window openings, and consist of posts, heads and sills, and are sometimes divided by horizontal members called transoms, and vertical pieces known as mullions. The posts and heads are generally bedded against plaster screeds, worked against brickwork, to prevent wind and rain entering at those joints, and to reduce the vibration caused by the opening and closing of doors and windows. The joints occurring between frames and stonework are usually pointed only.

Solid Window Frames.—These are used for fixed sashes, casement sashes, and sashes hung on centres. These frames always include head, posts, and sills (except in the circular form); the heads and sills are usually cut between the brickwork or masonry, and fixed by folding wedges as shown in figures 796 and 797. Water is prevented from passing through stone and oak sills by a metal water bar inserted in plough grooves sunk to receive it, as in figures 785 and 790.

The joints at head are tenoned, the post mouldings are scribed to the head. In the transom joint the mouldings on the post are scribed, the transom having a square shoulder. The mouldings on post are also scribed to sill. These frames should be double tenoned when above 4½" in width to exert a greater pressure on the shoulders.

Solid Door Frames.—These consist generally of two posts tenoned to head, which may be left projecting about 4½ inches, and built into wall. The joint at head of door frame is similar to that at head of casement frame. The feet of posts may be joggled to stone sills, as in figure 755. Sometimes instead of a joggle an iron dowel, about 3 inches long and 1 inch square, is used, as shown in figure 759; better still, cast-iron shoes, about ⅜ inch thick and 6 inches deep, with a joggle, are made to enclose the feet, as shown in figure 764. The shoes are sunk flush in the sides of the posts and the joggle in the sill.

Doors.—These may be divided as ledged, ledged and braced, framed and braced, and framed and panelled doors.

Ledged Doors.—These consist of a number of vertical battens, fixed by wrought-iron nails, driven in from the face of battens, and clenched to horizontal rails or ledges, as shown in figure 757.

Fig. 757.

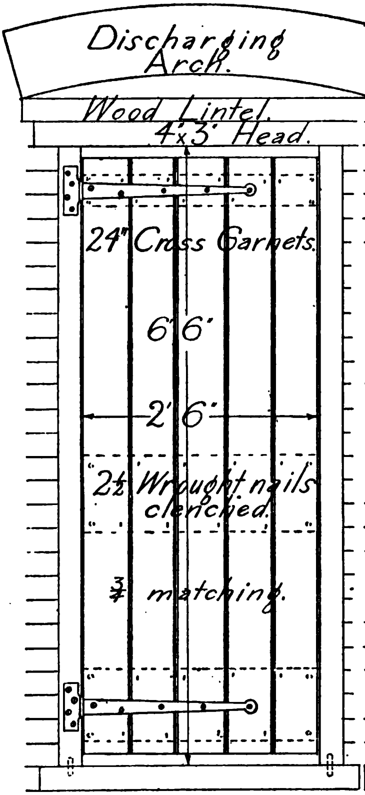
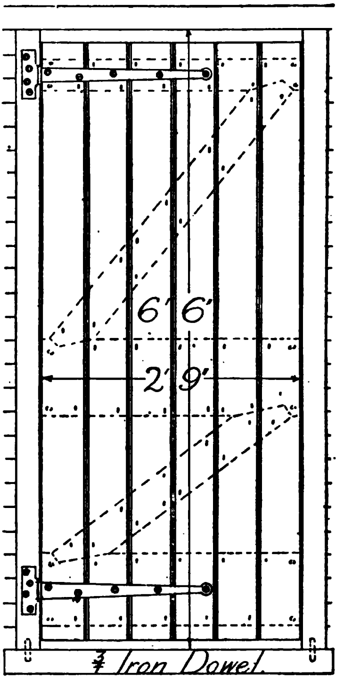


Fig. 759.



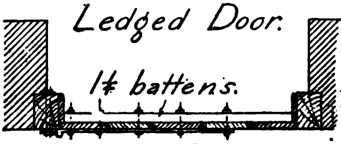


Fig. 758.

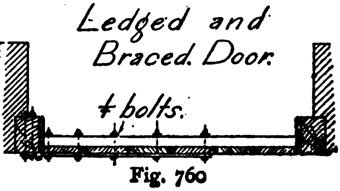


Fig. 760

This is the commonest description of door, and is used for temporary purposes, outhouses, etc. The battens may be square, ploughed and tongued, grooved and tongued, or chamfered, and are generally fixed to posts by cross garnets or strap hinges with screws or bolts.

Ledged and Braced.—These are doors made in a similar manner to the ledged doors, but having in addition braces, which stiffen the doors and keep the same from dropping at their free edge; the lower end of braces should always be near the supported edge. The joint with a brace and rail is generally made as in figures 759 and 760, which show the battens grooved, tongued, and V-jointed, and hung by cross garnet hinges.

Framed and Braced Doors.—These are a good and strong form of door, and extensively used for external work to withstand rough wear. A framing is made, styles and top rail being of equal thickness, bottom and middle rails with the braces having a thickness equal to the styles, minus the thickness of battens, all members flush on the back, as shown in figure 763. The bottom and middle rails are cut with barefaced tenons, and the braces may be stub-tenoned into rails and styles. The battens are then pushed into their position, and secured to rails and braces by wrought-iron nails hammered in from the face and clenched at the back. The battens extend from top rail to the ground, more effectively to let any water drain off the door that might fall upon it. Hook and eye or strap hinges are suitable for hanging these doors.

Framed and Panelled Doors.—These are described by the number of panels they contain, and consist of styles, rails, muntins and panels.

Four-panel Doors.—Figure 765 shows a four-panel door 7 feet high, 3 feet wide, and finishings for same, with all the

Fig. 761.

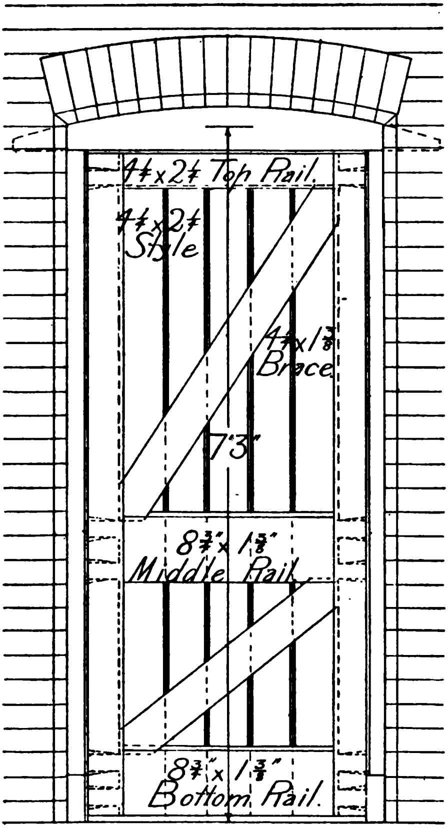
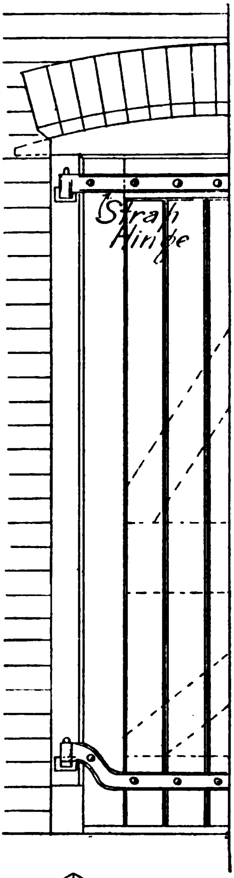


Fig. 762.



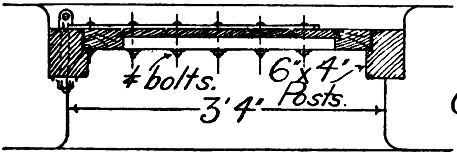


Fig. 763.

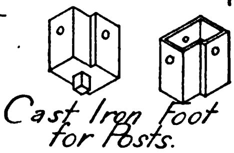


Fig. 764.

Figs. 761–764. Framed and Braced Doors.

Fig. 765.

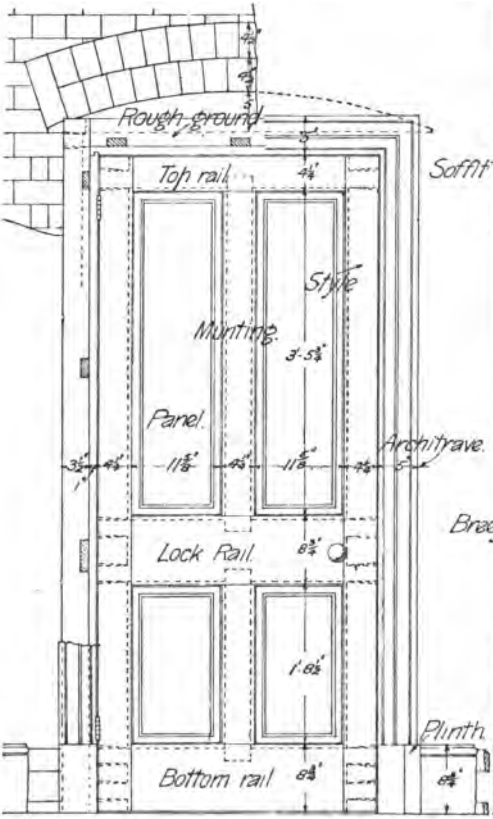
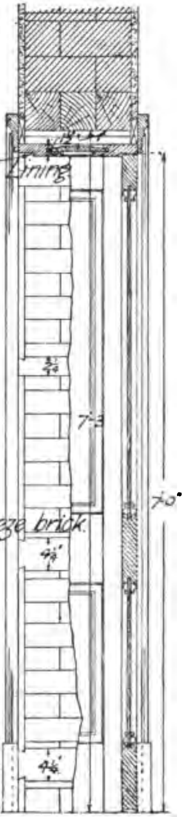


Fig. 766.



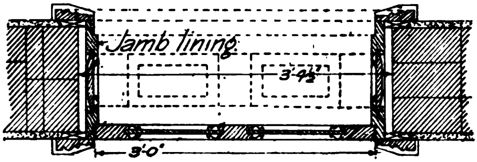


Fig. 767.

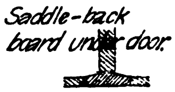


Fig. 768.

Figs. 765–768. Four-panel Door and finishings for same.

Fig. 769. Fig. 770.

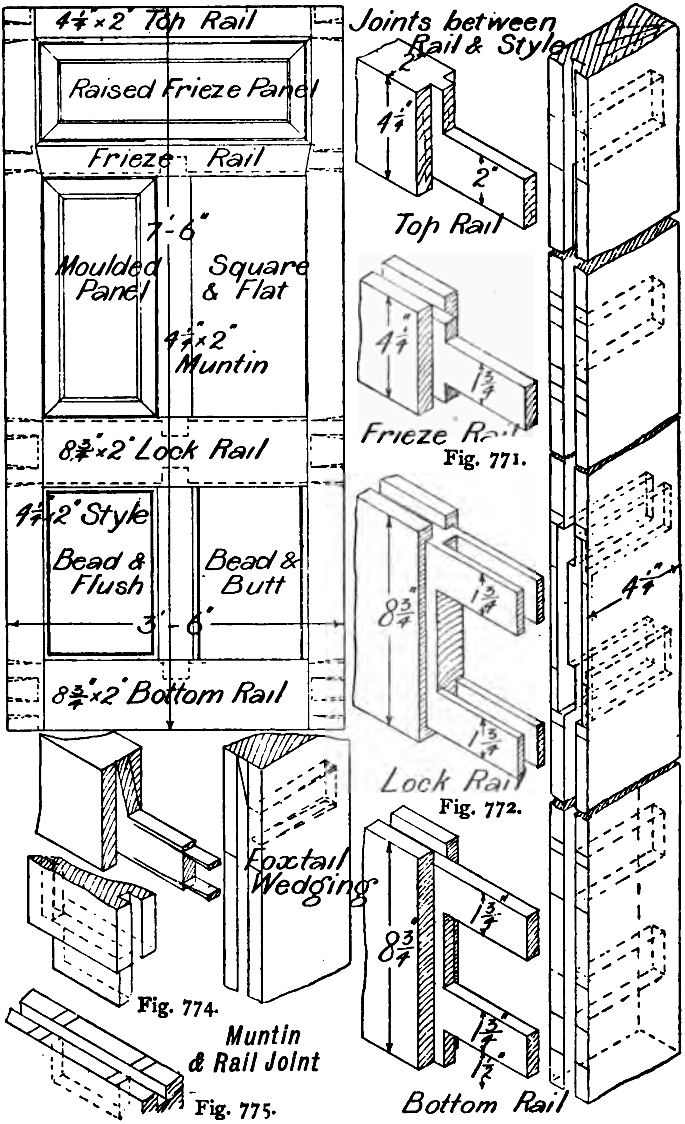


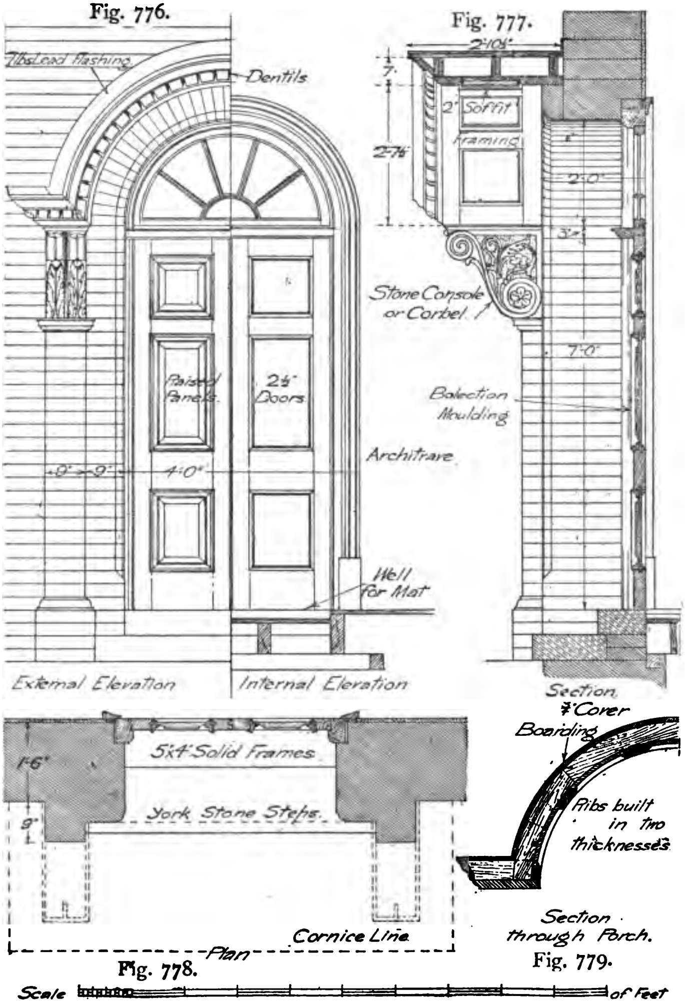
Fig. 771.

Fig. 772.

Fig. 774.

Fig. 775.

Figs. 769–775. Framing Joints. Fig. 773.



Figs. 776–779. Entrance Doorway—Folding Doors.

necessary dimensions. The height of the top line of middle or lock rail is usually between 3 feet 2 inches and 3 feet 6 inches, so that the handle of door coming in the centre of the lock rail may be at a convenient height. Doors are usually hung on butts, as in figure 765.

Five-panel Doors.—Doors 7 feet high and over that height are often divided into more than four panels, and the rail, between the top and lock rails, is called a frieze rail, and the top panel a frieze panel, as in figure 769.

Folding Doors.—A pair of doors hanging one on each door jamb or post, filling up the entire opening and usually with a rebated joint on the meeting styles. Figures 776 to 779 show an entrance with a pair of folding doors and fanlight over. On the outside opening, a porch is shown arranged about the semicircular head to the opening, it is supported by stone consoles springing from a brick pilaster. The semicircular covering is constructed about three built-up ribs, as shown in sections, figures 777 and 779. The soffit is framed and panelled, a moulded front and ¾-inch cover boarding fixed in narrow widths to receive the lead covering above. The fixing is obtained by plugging the wall and nailing to the plug through the wall rib, the lower portion of the porch is dowelled to the stone consoles.

Sash Doors.—These are doors the upper parts of which are arranged for glass panel or panels, the styles of which are sometimes narrower at their upper part to gain more light, and are called diminished styles, as in figure 780.

Chamfered Panels.—These are panels made of narrow battens, chamfered on edge, and together forming a V-joint, as in figure 761. The battens are sometimes cut and arranged diagonally.

Saddle-back Board.—In order to allow doors to easily clear carpets without having a wide joint at bottom when closed, a saddle-back board is fixed, as shown in figure 768, which allows a wide joint when door is open. This method is often adopted in Ireland.

Sashes.—These are frames formed of styles, rails, and bars, which are rebated to receive glass panels, and the wood members

Fig. 780.

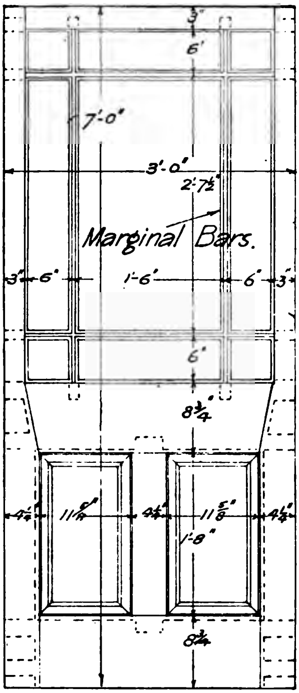
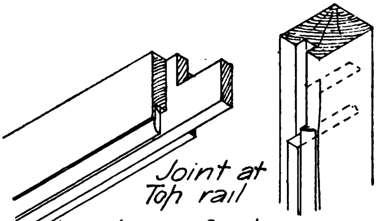


Fig. 781.



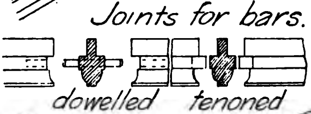


Fig. 782.

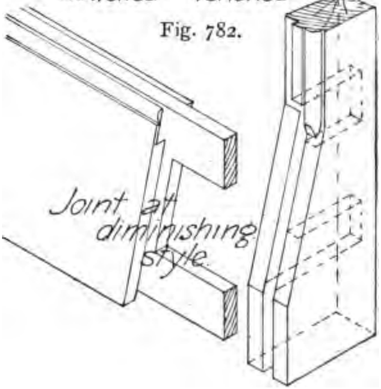


Fig. 783.

may be plain, chamfered or moulded. The rails are tenoned to the styles, and ends of bars may be tenoned to styles, rails or bars, or where intersecting another bar may be scribed and dowelled, as shown in figure 782, or scribed and tenoned. The through bars of sashes, if they be rectangular, should be across the narrowest width, or in the direction of the impact or stress. In double hung sashes and those hung on centres the through bars would be vertical, in casement sashes would be horizontal.

Sashes hung on Centres.—For factories, stables, lantern lights, and other positions where economy is an object, or in positions that would be inconvenient to be hung with weights on cords, sashes hung on centres in solid frames are employed, and are especially suitable to obtain light and air in high positions that are not easy of access, as these sashes are hung on iron centres or pivots, higher up than their centres of gravity to allow for the weight of the cord attached to it, so that the window may be closed by its own weight from below by simply taking the cord off the cleat on which it is usually wound. These sashes require carefully fitting and the beads cut as in figure 787, otherwise the wind and rain will find a passage through the space between the beads fixed on the sashes and the frames. To admit sash being taken out, grooves are sunk in the beads, as shown in figure 787.

Sometimes the outside edge of the style is plough grooved, so that when the sash is opened horizontally it may be taken out of the frame. This avoids the grooving of the beads that are fixed on the sashes, and, if the groove on the edge is no objection, greatly simplifies the work.

Sliding Sashes are said to be single hung when one sash is fixed, or without cords, weights, and axle pulleys.

Double Hung Sashes and Cased Frames.—Usually in dwelling-houses this method is adopted, owing to the efficiency in keeping out the weather, the ease with which the sashes can be raised or lowered, and the small amount of space occupied and required for working. The frames are made of linings enclosing a space (for the weights to move up and down, which balance the sashes), and consist of pulley styles, pulley head, oak sill, inside and outside linings, parting bead, inside bead, parting slip, back

Fig. 784.

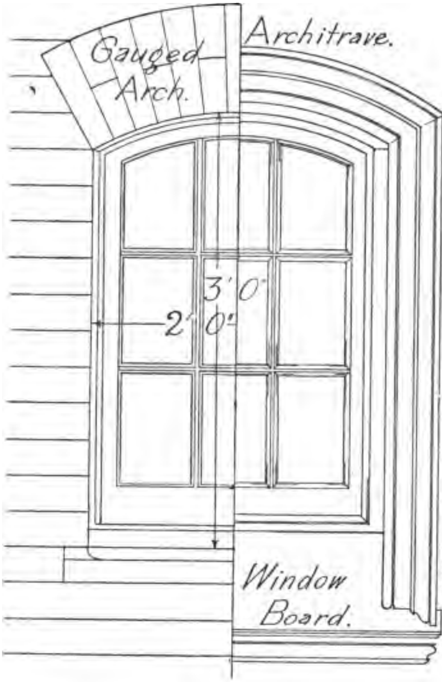


Fig. 785.

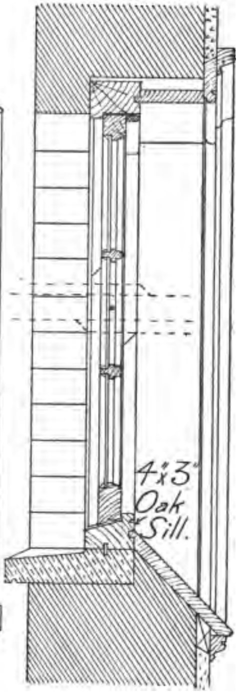


Fig. 786.

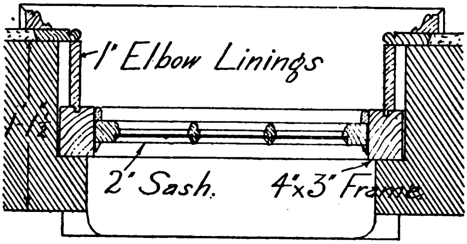
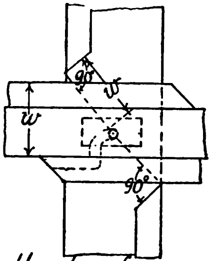


Fig. 787.



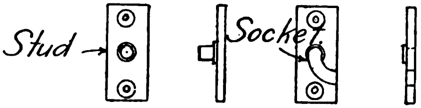


Fig. 788.

Figs. 784–788. Sash rotating upon Centres.

linings, angle blocks, brass axle pulleys, and are known as cased frames or boxings. There are two sashes, top and bottom, which consist of top and bottom rails, meeting rails, styles and bars, which are suspended by cords and weights. Figures 789 to 791 show an opening filled in with double hung sashes and cased frame, having rebated meeting rails, to prevent sash fastener being opened from outside; sometimes the bead fixed on the oak sill and shown in section is replaced by a narrow lining 3″ deep and of the thickness of the bead (a similar bead may be worked on this member), to allow bottom sash to be raised about 2 inches so as to admit air without draught; and the vertical sash beads fixed by screws in cups to allow of their being taken off and refixed for repairs or window cleaning, without any damage to bead or frame.

Casement Sashes and Frames.—Where sashes are hung by one of their vertical edges, they are called casement sashes. It is a method most commonly employed on the Continent; they are convenient to be used as doors. The sashes and frames may be constructed to open outwards or inwards.

Sashes opening outwards present no great difficulty in obtaining watertight joints, but have this objection, that if a sash should happen to be left open, without being secured, the wind may act upon it and smash the glass, which in high situations would be dangerous. The joints in sashes opening inwards are very difficult to get wind and watertight; but for this objection they would undoubtedly be more frequently used, as they possess the advantage of being much easier to clean than any other method of fixing sashes, and the danger consequent thereon is reduced to a minimum.

Sashes opening outwards.—The members of frames for these sashes are rebated from the outside.

Sashes opening inwards.—Figures 792 to 799 give an illustration of a pair of casement sashes, opening inwards, in

Fig. 789.

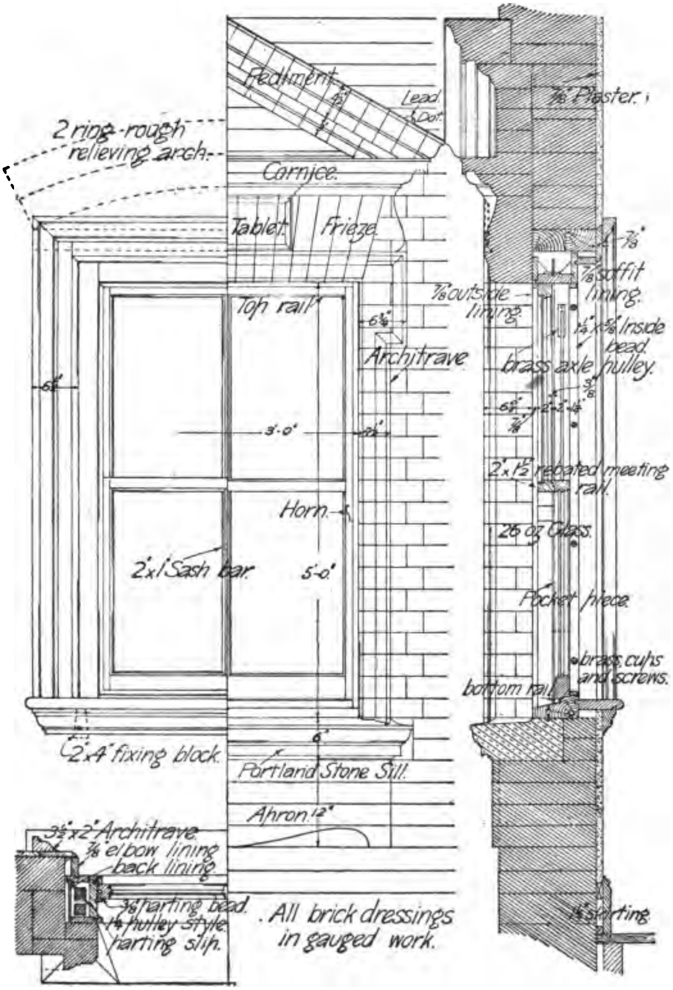


Fig. 791. Fig. 790.

Figs. 789–791. Double-hung Sashes and Cased Frame.

solid frames, showing a metal water bar on bottom rails, and is very effectual in withstanding a driving rain. At the seaside, or in places exposed to the weather the use of a metal water bar becomes a necessity; in sheltered situations a wood water bar may be used. The outer meeting style has a projecting

Fig. 792.

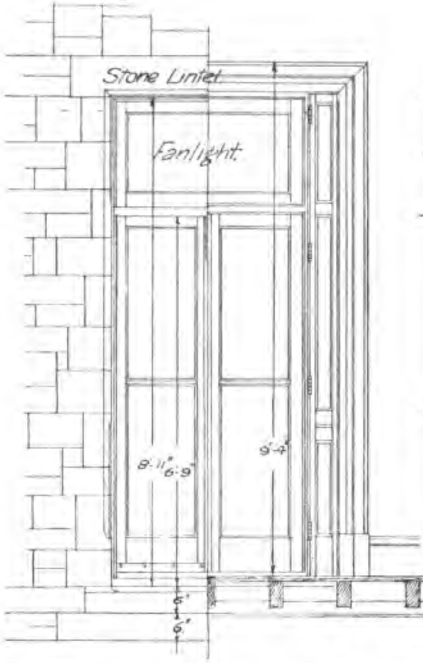
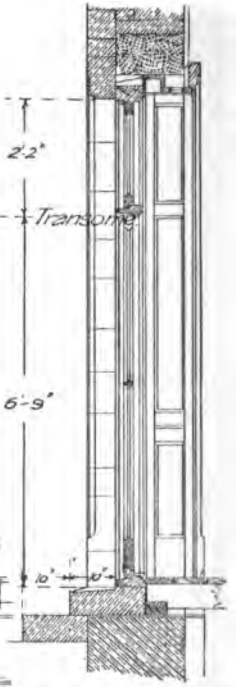


Fig. 793.



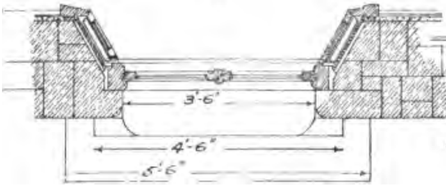


Fig. 794.

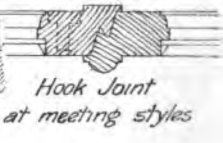


Fig. 795.

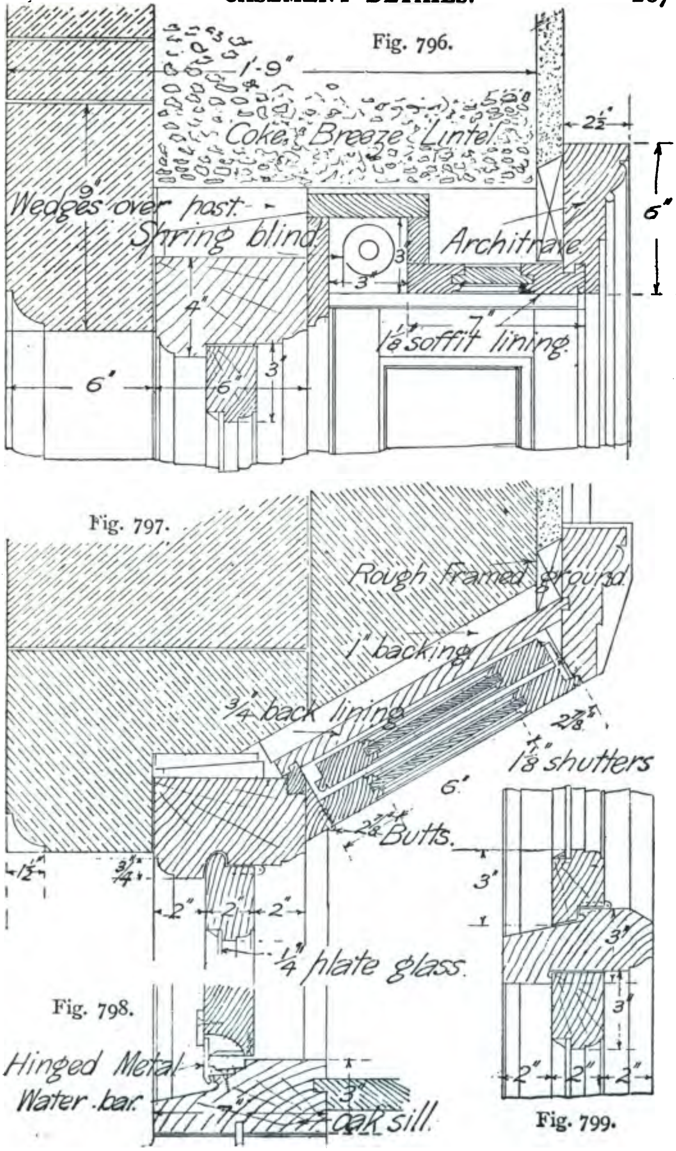
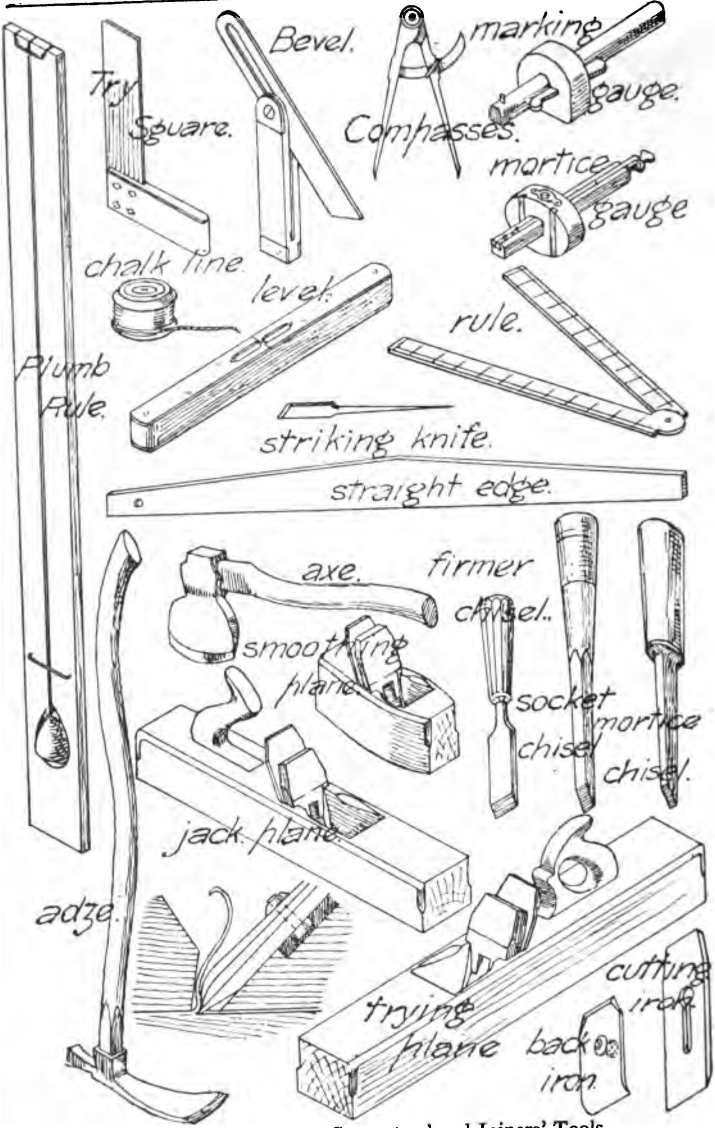
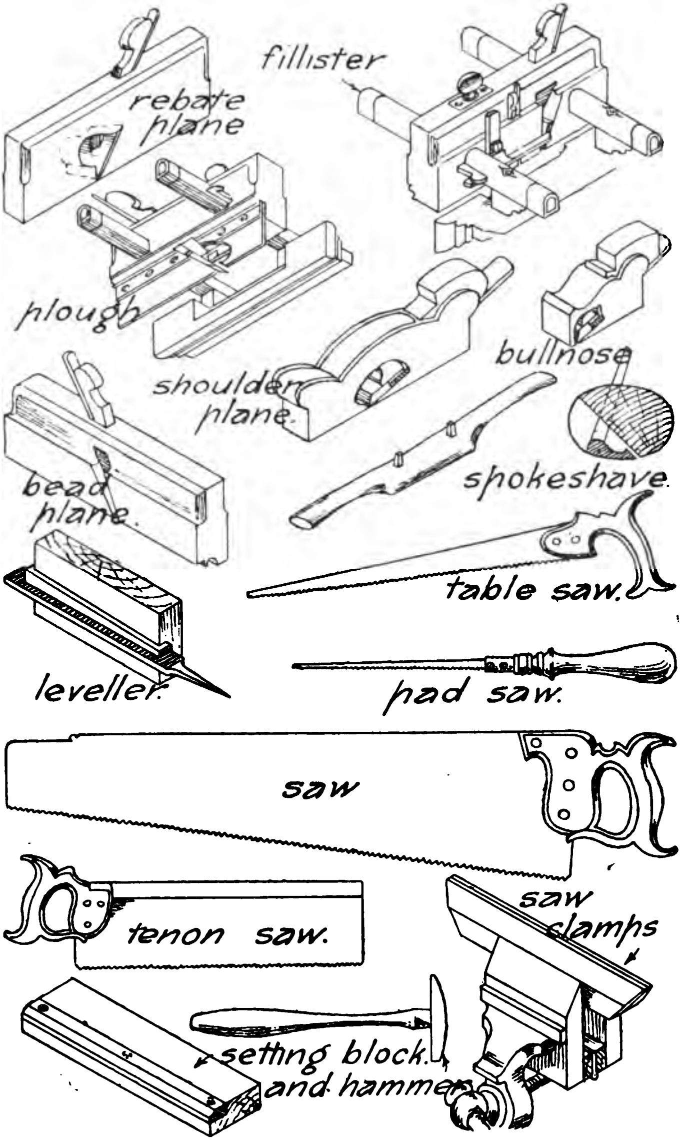


Fig. 796.
Fig. 797.
Fig. 798.
Fig. 799.

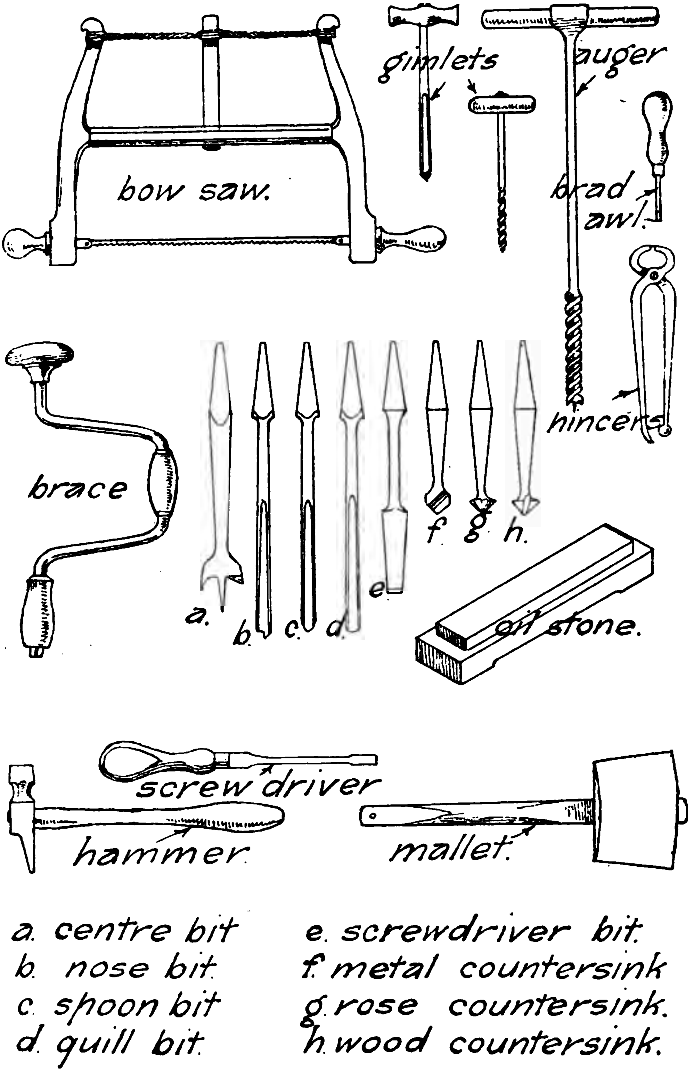
Figs. 796-799. Casement Sashes and Frames.


Try Square.
Bevel.
Compasses.
marking gauge.
mortice gauge
chalk line.
level.
rule.
Plumb Rule.
striking knife.
straight edge.
axe.
firmer chisel.
smoothing plane.
socket chisel
mortice chisel.
jack plane.
adze.
trying plane
back iron.
cutting iron.

Figs. 800—821. Carpenters' and Joiners' Tools.



Figs. 822–837. Carpenters' and Joiners' Tools, continued.



Figs. 838—856. Boring and Miscellaneous Tools.

moulding worked on it, or in inferior work this may be planted on, to protect the vertical joints between the meeting styles. The hanging styles have a tongue worked on to fit into grooves sunk in the posts, and they are secured on the inside by bolts. Sometimes an espagnolette bolt is employed, which combines handle, top and bottom bolts, and the sash may be loosened or closed by one turn of the handle.

Hook Joint.—Figure 795 shows a draught and weather-resisting arrangement worked upon the meeting styles, and is termed the hook-joint.

Shutters.—Figures 792 to 797 show an arrangement of boxing shutters.

Tools.—The ordinary tools of the carpenter and joiner comprise setting out, cutting, boring and miscellaneous tools. Figures 800 to 810 show the setting out tools, the square, bevel, compass, gauges, rule, level, plumb rule, chalk line, striking knife and straight edge; figures 811 to 831 show those used for cutting purposes, the axe, adze, chisels, bench planes, rebate planes, fillister, plough, shoulder, bull nose, and bead planes; spokeshave, table saw, pad saw, hand saw, tenon saw and bow saw. Figures 839 to 851 show the boring tools, consisting of brad-awl, gimlets, auger, centre bit, nose bit, spoon bit, quill bit, screw-driver bit, metal countersink, rose countersink, wood countersink, and the brace. The miscellaneous include the hammer, mallet, screw-driver, pincers, oil stone, leveller, clamps, setting block and hammers for the sharpening of saws.

Hinges.—Figures 857 to 866 show the types of hinges in common use.

Figure 857 shows the butt hinge used for hanging doors that are sufficiently thick to have the hinge let in to the edge of the door.

Figure 858 is the rising butt hinge, the wearing surfaces of the two leaves are formed as helical curved surfaces, the purpose being to cause the door to rise as it is opened, and thereby

Fig. 857.

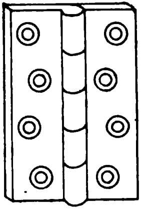


Fig. 860.

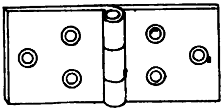
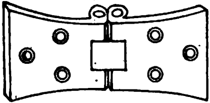


Fig. 863.



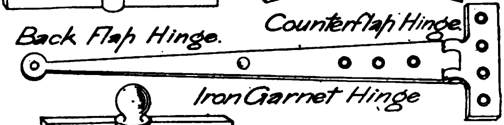
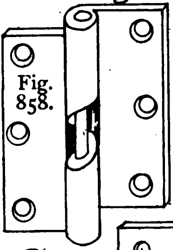


Fig. 861.

Fig. 858.



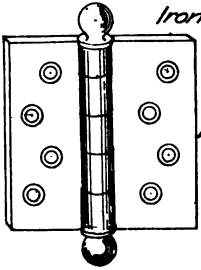
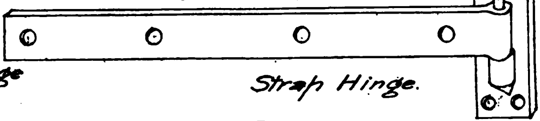


Fig. 859.

Fig. 862.



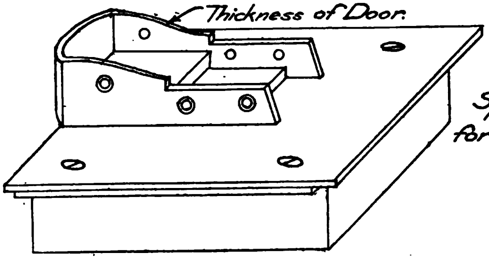


Fig. 864.

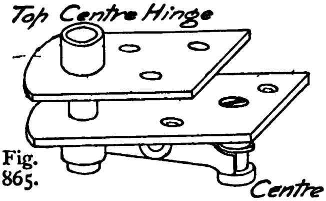


Fig. 865.

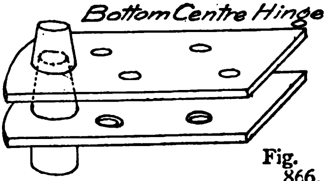


Fig. 866.

Centre Hinges

Figs. 857-866. Various Hinges.

clear any small obstruction, such as carpets, etc., also to allow the door to close automatically.

Figure 859 shows the pin hinge, used for the hanging of heavy doors. The centre pin may be withdrawn, this renders it convenient to fit the two halves of the hinge without lifting the heavy door at each time it is offered up during fitting.

Figure 860 illustrates the back flat hinge, employed where the doors, shutters, etc., to be hung are thin, and consequently no room on the edge for a butt hinge.

Figure 861 shows the cross garnet, largely used in the hanging of thin match-board doors. They are screwed on the faces of the doors.

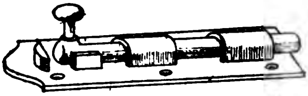
Figure 862 shows a strap hinge, used in heavy external work, such as stable doors, gates, etc. They are bolted on to the face of the work. The two parts are loose, thus permitting the work to be lifted off.

Figure 863 shows a counterflap formed in three parts and having two centres. This arrangement allows the two eaves to be folded back to back.

Figure 864 shows a spring hinge for a swing door. It consists of a metal box, containing a strong steel spring, this actuates a metal socket into which the heel of the door is fitted, the spring always tends to keep the socket in a central position and the door closed.

Figure 865 shows the top centre hinge used in connection with the previous example. It consists of two parts, an adjustable pivot which is let into the frame and a socket let into the head of the door. The centre is arranged to be adjusted by means of a screw worked from the face at the opposite end of the plate from the pivot. The pivot and screws are attached to the opposite ends of a rocker fixed to a centre on the back of the plate, as shown in the figure 865. To hang a swing door, the bottom spring hinge and the top centre are fitted to the door. The door is then pushed into the bottom socket and revolved on the bottom centre to a

Fig. 867.



Tower Bolt

Fig. 876.

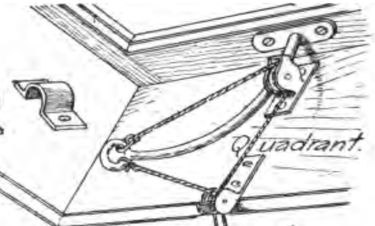
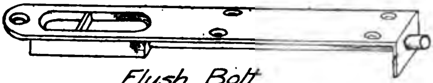


Fig. 868.



Flush Bolt

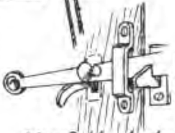
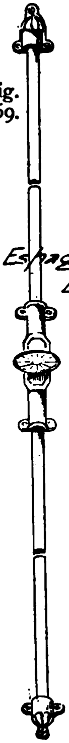


Fig. 875.

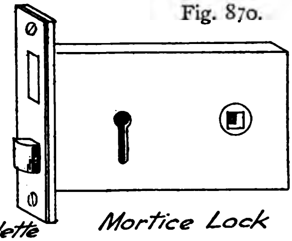
Norfolk Latch

Fig. 869.



Espagnolette Bolt

Fig. 870.



Mortice Lock

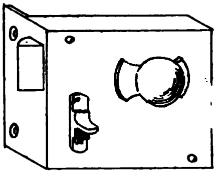
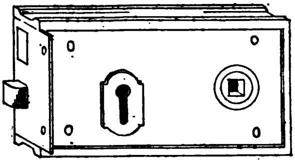


Fig 873.

Night Latch.

Fig. 871.



Rim Lock

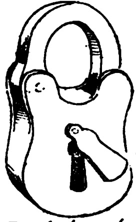
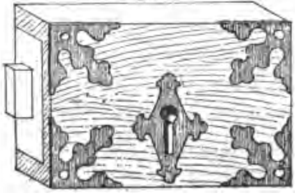


Fig. 874.

Pad Lock

Fig. 872.



Stock Lock.

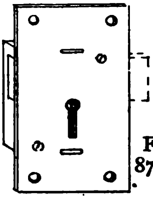


Fig. 874a.

Cupboard Lock.

Figs. 867–876. Locks and Fastenings.

position at right angles to that occupied by the door when closed, the top socket is then carefully centered under the pivot, the screw attached to the rocker is then turned, causing the centre to protrude into the socket, thus fixing the door.

Figure 866 shows a bottom centre hinge used for swing doors where it is unnecessary for the door to close automatically. It consists of a metal pivot and socket.

Locks and Fastenings.—Figure 867 shows a tower bolt used for fixing to the back faces of external doors.

Figure 868 illustrates a flush bolt. These are let into the doors either upon a face or an edge of a door, and flush with the surface. They are used where the projecting tower bolt would be objectionable. Figure 869 illustrates the espagnolette bolt, used for securing casement windows. They consist of two long bolts, one of which secures the top and the other the bottom of the sash. Both bolts act simultaneously by turning the handle or lever in the centre. Figure 870 shows a mortice lock. These are employed for doors 2 inches and above in thickness. They are let into the edges of doors. Figure 871 shows a rim lock. These are used for thin doors, and are screwed on to the face and the edge of the door.

Figure 872 illustrates a stock lock, which consists of a rim lock encased in hard wood. They are used for stables, church work, &c., and are frequently bound with iron of a more or less ornamental character. They are usually dead-shot locks; that is, to be opened by a key only. Figure 873 illustrates a night latch, used for external doors. They are a form of rim lock, opened on the inside by a drawback knob and from the outside by means of a key. Figure 874 shows a padlock and hasp used for securing doors in temporary and common work. Figure 875 shows a Norfolk latch used in inferior doors; but ornamental types of same are frequently used in ecclesiastical work. Figure 876 illustrates a quadrant and wheels employed for the opening of skylights and sashes in positions not easily accessible.

CHAPTER XII.

PLUMBING.

Coverings.—External plumbing work consists of covering roofs entirely with sheet lead, or those parts on slated or tiled roofs which cannot be made watertight with the latter materials. For flats, gutters, flashings, etc., lead far surpasses any other material, and combines lasting and waterproof properties. In towns, lead coverings are more economical than zinc. Zinc lasts well in the pure air of the country, but when exposed to the deleterious effects of sea air, or the smoke-laden atmosphere of large towns, it is readily destroyed.

Sheet lead, for external work, is obtainable in two forms, cast and milled.

Cast Lead.—The lead is melted and run into sand-covered moulds to form sheets of the required size, and may be obtained up to 16 feet in length and 7 feet in width. Cast lead is very durable under great changes of temperature, and, being very soft, is suitable for positions where subjected to traffic, but it is subject to flaws and sand holes.

Milled Lead.—Slugs or thick cakes of lead are cast and then passed between rollers to reduce them to the desired thickness. Sheets may be obtained in lengths of 35 feet and widths up to 9 feet. Milled lead is more uniform in thickness than cast lead, and is freer from the sand holes and flaws, but is not nearly so durable for roof coverings, nor is its resistance to wear equal to that of good cast lead.

Laying Sheet Lead.—The boarding to receive sheet lead should be perfectly smooth. All the joints should be traversed by a plane to take away any projecting arrises which would, sooner or later, show through the lead, especially after wet weather. There should be no sharp angles, and all projections should be rounded off. The grain of the boarding on flats and gutters should be laid in the direction of the current, in order that any corrugation formed by the casting of the boards should not retain pools of water.

The soles of gutters are recommended to be formed by narrow boards 4½ inches wide, nailed with the heart side upwards, so that the edges will press tightly against the bearers if the boards cast; the boards should be well nailed, about 1¼ inch from each edge. The width of joints, caused by shrinkage, is obviously much less in narrow than in wide battens.

In fixing lead, the sheets should be free to contract or expand, or pieces used be of such small dimensions that the contraction or expansion will be inappreciable; this is practically satisfied at ordinary temperatures when the lengths of the pieces do not exceed 7 feet. The joints made between the edges of lead must be arranged so that no water can pass through, or the covering be blown up by the wind. If the above conditions are not taken into consideration the force of expansion and contraction will cause the sheet lead to slide down if fixed in inclined positions, or buckle and rise in the centre if it be laid on a flat.

Expansion of Metals.—The following table gives the expansion of the metals used in construction due to heat, between the temperatures of 32° and 212° Fahr. To find the expansion due to an alteration of temperature of one degree, divide the tabulated number by 180:—

Cast Iron	1 part in 889
Wrought Iron	1 ,, 819
Steel, Untempered	1 ,, 927
Steel, Tempered	1 ,, 807
Lead	1 ,, 349
Zinc	1 ,, 340

Specification of Lead Coverings.—The following are the weights of lead recommended for the various parts of external coverings:—

Roofs, Flats, and Main Gutters ...	7 lb. to 8 lb. lead
Hips, Ridges and Small Gutters ...	6 lb. to 7 lb. ,,
Flashings	5 lb. ,,
Cisterns, bottom	7 lb. to 8 lb. ,,
,, sides	6 lb. to 7 lb. ,,
Sinks, bottom	7 lb. to 8 lb. ,,
,, sides	8 lb. to 10 lb. ,,
Soil Pipes	8 lb. to 10 lb. ,,

Lead is usually described and specified by its weight in pounds per superficial foot. The following table gives the thickness of milled lead in common use. The thickness, it may be noticed, is nearly 17 thousandths of an inch for each pound in weight per superficial foot:—

Weight in lbs. per foot super.	Thickness in inches.	Weight in lbs. per foot super.	Thickness in inches.
1	0·017	7	0·118
2	0·034	8	0·135
3	0·051	9	0·152
4	0·068	10	0·169
5	0·085	11	0·186
6	0·101	12	0·203

The lengths of pieces of lead generally used in practice for gutters or flats should not be more than 9 feet, and the fall or inclination of the gutters or flats should not be less than 1 inch in each 9 feet of length. Cover and step flashings should not exceed 6 feet, and ridge pieces not more than 7 feet in length. Dormer cheeks, if very large, should be put on in two or more pieces. Large dormer tops should have a roll fixed upon them, but for small dormers the lead can expand over the edges.

Nailing.—Copper nails should be used, but nailing should not be resorted to unless absolutely necessary.

Bossing.—That is, working the lead to the required form with boxwood tools—is preferable to soldering such angles as the returned ends of gutters, drips, or cesspools, or any position where the perpendicular part does not exceed 12 inches in height.

Lead Tacks.—These are narrow strips of lead from 2 to 4 inches in width, used for fastening the free edges of flashings, ridge coverings, apron pieces, etc. They are termed *tingles* in the north of England.

Laps or *Passings.*—The distances pieces of lead lap over the adjoining pieces in aprons for gutters, stepped flashings, ridge coverings and other situations where it would be unwise to have the lead in one continuous length. The usual length of passings is 4 inches for upright and 6 inches for horizontal work.

Raglets.—The grooves or chases, usually 1½ inch deep, cut into stone walls to receive the upper edges of the lead flashings.

Fixings for Flashings.—Where fixed to brick walls a small slightly inclined fillet of cement should be made on the lower side of the horizontal joint, and the lead flashing secured in it by lead wedges varying from 3 to 9 inches apart. The open joints between the wedges should be pointed in cement in brick walls, or with mastic, or be run with lead if in stone walls.

Cover Flashings.—The name given to the lead coverings over the turned-up parts of lead gutters or flats: they are usually about 6 inches wide, the object being to keep water from passing between the turned-up lead and the wall, and to allow the covered sheet freedom to contract or expand.

Apron Pieces.—The name applied to the lower horizontal flashing of a chimney shaft, skylight, dormer, or wall penetrating a roof, as shown in figures 898 to 901.

Tilting Fillets.—These are pieces of wood, triangular in section, and are used where inclined surfaces abut against walls in order to tilt the slates, and so convey the water away from the walls. Wood fillets are also fixed under the eaves courses of slates, so that they may lie close, and thus prevent the wind getting under them, as shown in figures 897 to 900.

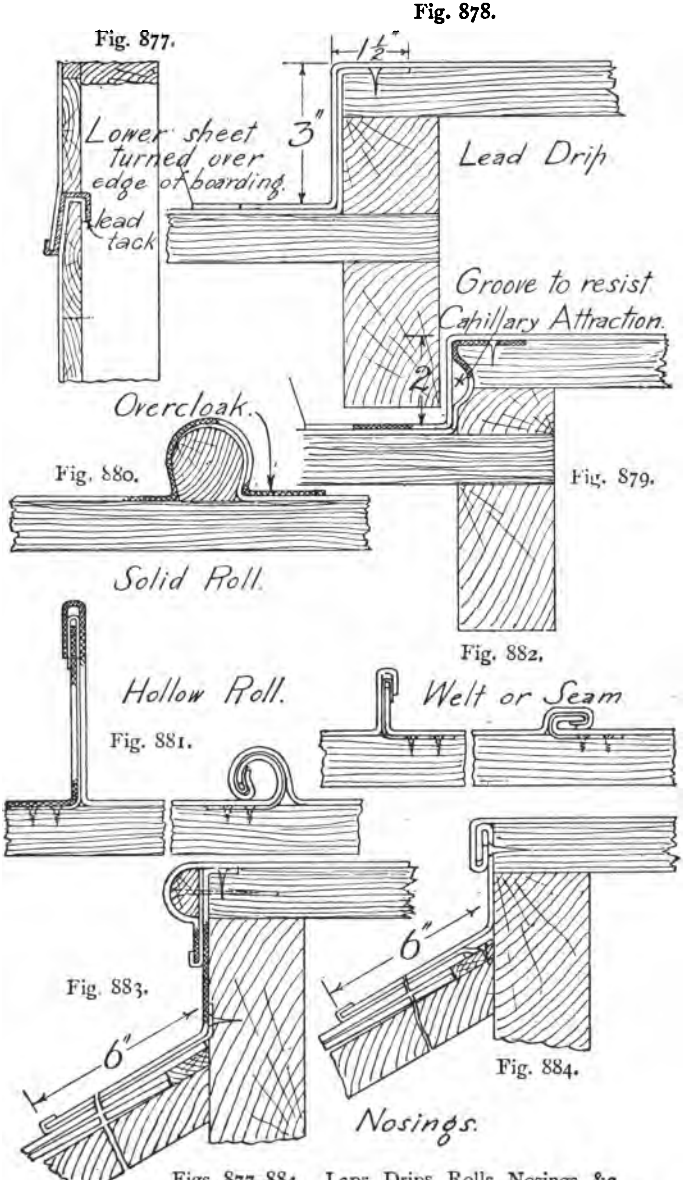
Cement Fillets.—To save the expense of lead flashings, fillets, composed of equal portions of Portland cement and sand, are run along the junction of lean-to roofs with walls, but the cement sometimes shrinks, or breaks away, resulting in an open joint, thus failing to answer the purpose for which it is intended. Zinc soakers, together with cement fillets, are more effectual and are extensively used in cheap buildings, but are not nearly so durable as lead soakers and flashings.

Joints.—The joints most extensively used for lead coverings for external work may be classified as follows:—

Joints across the Flow or Current.—Lap and drip joints.

Joints parallel with the Flow.—Rolls, hollow rolls, and seams or welts.

Lap Joints.—These are horizontal joints on inclined surfaces of pitched roofs covered with lead. The boarding should be placed at right angles to the inclination. The sheets of lead should be fixed between the rolls, the upper ends being turned over the edge of the boarding and nailed, so that the sheets are secured along the entire length of the top edge. This effectually resists the tendency to crawl down the slope of the roof, and is far better than nailing to the face of the boarding. The lower edge of the upper sheet laps over the top edge of the lower one. If the covering is on a vertical surface, as



Figs. 877–884. Laps, Drips, Rolls, Nosings, &c.

shown in figure, 877 a 4-inch lap would be sufficient; but if the surface has an inclination of not less than 45°, a 6-inch lap is necessary. If the inclination is less than 45° the lap would require to be increased considerably, or a drip would have to be formed.

Drips.—Large flat roofs and very long gutters are constructed of a number of plane surfaces slightly inclined and raised a short distance one above the other, forming, when finished, a number of low steps called drips, which should not be at a greater distance than 9 feet apart. Drips should be made 3 inches in depth, as shown in figure 878, to resist the power of capillary attraction; but when made 2 inches or less, they should have a groove formed, as shown in figure 879, to resist that force. For economical reasons, drips in gutters are often made less than 2 inches deep, but this results in water being drawn between the laps of the lead and in the rotting of the woodwork.

Rolls.—On flats, or at the ridge or junction of the two opposite slopes of a gutter or roof, wooden rolls 1¾ inch diameter and upwards are fixed at the joint. Sheet lead is dressed round the roll, and well into the angles, to obtain a firm grip, as in figure 880.

Hollow Rolls.—The method of forming rolls without a wooden core has been very extensively used on steep-pitched roofs on large buildings, such as cathedrals and abbeys, and was the common practice in the mediæval ages.

To make a hollow roll, copper or lead tacks, about 6 inches long and 2 inches wide, are secured by two screws each to the boarding, about 2 feet apart, the edges of the lead bay are turned up, as shown in section figure 881, and are then ready to be folded over. The folded edges are then dressed to enclose a hollow, as in section figure 881. Although this is a good method of forming rolls, it is not suitable for positions where any traffic is likely to come upon them.

Nosings.—At the boundaries of flats adjoining sloping roofs, or at the intersection of two differently inclined surfaces, as at the curb of a mansard roof, the lead covering may be terminated as a nosing, the object being to secure the ends of the lead laid on the flat, and yet allow them to shrink or expand freely. Figure 883 shows a flashing of 6-lb. lead, with the lower half laid on the slates, and the upper part dressed against the vertical boundary of the flat. A wood nosing is nailed over the top edge of the lead, thus firmly securing the flashing, and the ends of the lead bays are then dressed round the nosing. The lower edge of the flashing is secured from being torn up by the wind by means of lead tacks, which are better than soldered dots, and allow the flashing to expand and contract.

Figure 884 shows a flashing secured by copper nails, instead of being covered by a wood nosing, and flat welted nosing turned, for preventing the wind getting under the ends of the lead bays.

Figure 885 is an elevation, and 886 a section showing the method of forming nosing for the curb of a mansard roof.

Welts or Seams.—The joints for sheet lead when running with the current on vertical surfaces may be the flat welts or seams. These are made by fixing lead or copper tacks about 2 feet apart at the junction of the lead sheets; the edges of the bays are bent up and turned over together, and then dressed flat, as shown in figure 882. For flat pitched, or horizontal surfaces, seams are not so good as rolls.

Ridge Coverings.—Six-lb. lead is the thickness usually adopted for ridge coverings; the lengths of the pieces should not exceed 7 feet.

The lead should be dressed over a wood ridge roll, which should not be less than 2 inches in diameter, and may be fixed in one of two ways: First, by double-pointed nails, in which case the lead tacks that support the lower edge of the ridge coverings pass beneath the roll, and are secured by it, as

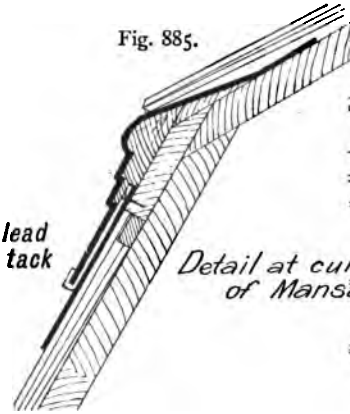


Fig. 885.

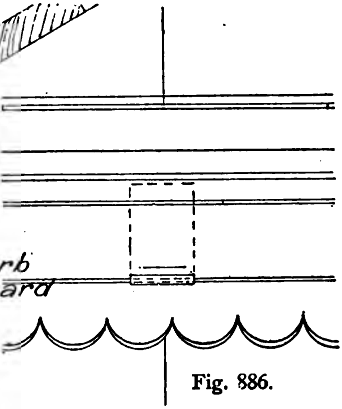


Fig. 886.

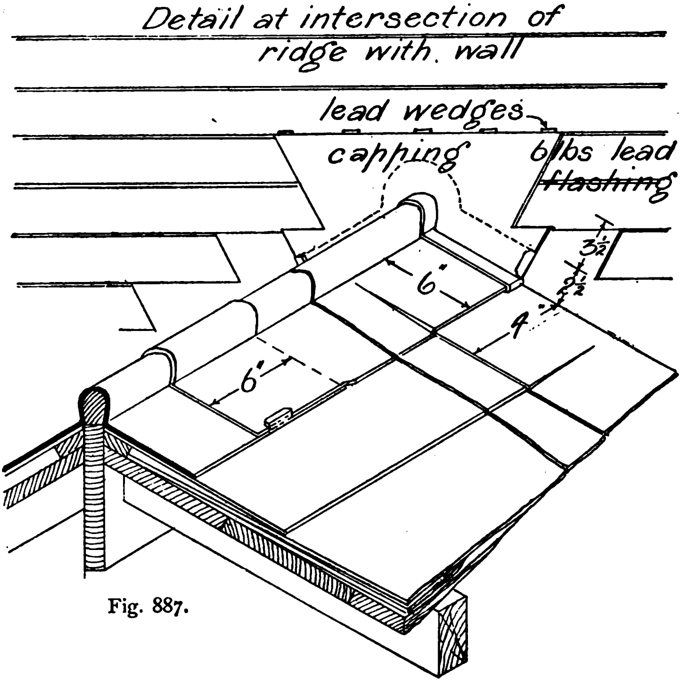


Fig. 887.

Figs. 885–887. Nosing and Ridge Coverings.

shown in figure 888; secondly, by nailing to the ridge piece, as shown in figure 887, the lead tacks being secured to the ridge piece before the ridge roll is fixed. The lead wings should be dressed close to the bottom of the roll, and extend 6 inches down the slope on either side of the ridge, the free edges being secured by lead tacks.

Lap joints are formed at the junctions of the ridge pieces. This has been objected to on the grounds that water is liable to be drawn between the sheets by capillarity or driven in by the wind; or drain in if the ridge is not perfectly level. These objections may be obviated by forming a water groove in the lap, the under piece of lead being dressed into the groove. Any water getting between the laps on the sloping sides would fall on the slates and drain off.

Difference between Valleys and Hips.—If the upper surfaces of the slopes of two adjacent roofs include an angle less than 180°, or, in other words, form a hollow, it is termed a valley; but if the angle be greater than 180°, thus forming a ridge or projection, it is called a hip.

Hips.—These may be made watertight in two ways. First, by dressing a piece of lead, of the required width and not longer than 7 feet, over a roll, and letting the sides lie 6 inches on the slates similar to a ridge. To prevent the lead sliding down the hip, the lowest piece of roll being fixed, the first piece of lead is laid on with the ends extending 6 inches beyond the roll ends, as shown in figure 889, the lead is then bossed down. The next length of roll is then fixed in position, and the lead put on with its lowest extremity resting on the upper end of the first piece of lead. The bottom end of the second piece of lead laps over the first piece 6 inches. Lead tacks should be fixed about 3 feet to 3 feet 6 inches apart, and the lower piece should be clipped over the upper at each lap joint. Secondly, the hip may be formed by soakers, which may be fixed over a roll, as shown in figure 891, where

Fig. 888.

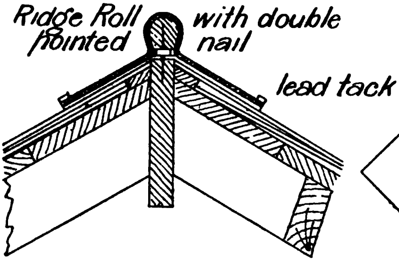
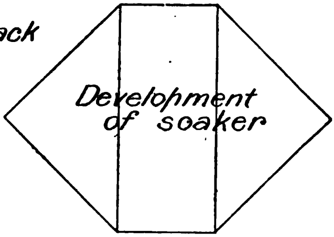


Fig. 890.



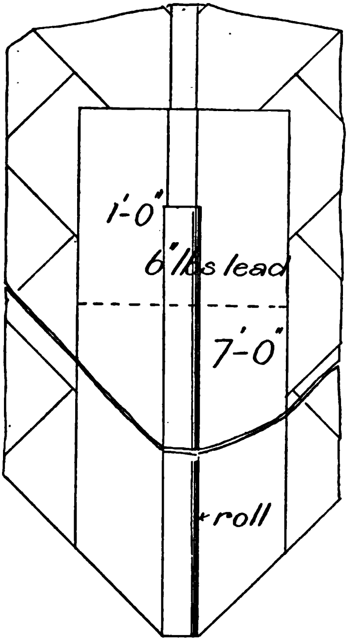


Fig. 889.

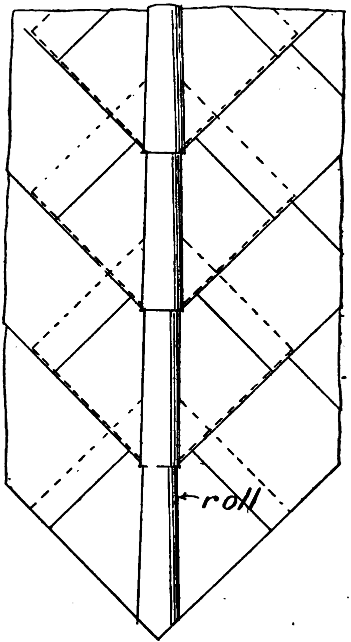


Fig 891.

Figs. 888–891. Hip Coverings.

they are visible, or the roll may be dispensed with, in which case there is a saving of lead. The roll is the best, as it forms a wind guard to the slate edges on the hip.

Figure 890 shows a plan of a hip soaker.

Valley Coverings.—In valleys, the coverings may be arranged to form gutters, small fillets being fixed on the slopes of the roofs to tilt the slates, as shown in section figure 892.

Stepped Flashings.—The joints between sloping roof surfaces and end walls built of brickwork or stone rubble are best protected by means of pieces of sheet lead, called stepped flashings, 6 inches lying on the roof and 6 inches against the wall. The upper edges are turned 1 inch into the raglets or joints of the brickwork prepared to receive them, and are fixed as described in the paragraph on flashings. Figure 898 refers to this kind of flashing. To set out stepped flashings, first roll out the piece of lead, which should be 13 inches wide, then fold it lengthways in the centre, like the letter L. Draw a line, 2½ inches distant from the angle, on the stand-up side. This line is usually called the "water-line." The piece of lead should then be laid in position on the roof, and the horizontal joints in the brickwork transferred to the lead between the top edge and the water-line. Next draw lines from the points where the horizontal lines cut the water-line to the point where the horizontal line immediately above cuts the outer edge of the piece of lead. Draw other lines 1 inch distant, parallel with and above the horizontal lines. The small triangular pieces of lead above these last lines to be cut out with a knife. The pieces between the parallel lines to be folded and wedged into the raked-out joints of the brickwork.

Raking Flashing.—The name given when the turned-up edge of a flashing is secured to a chase or raglet, cut parallel to the slope of a roof. This method is adopted for stone walls adjoining sloping roofs.

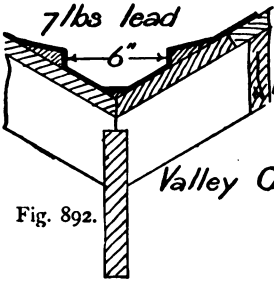


Fig. 892.

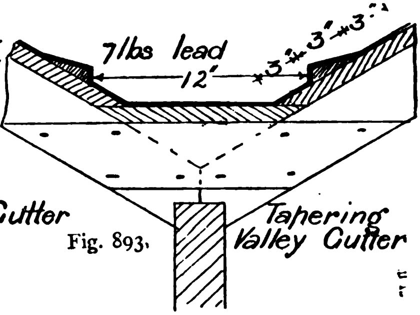


Fig. 893.

Fig. 894.

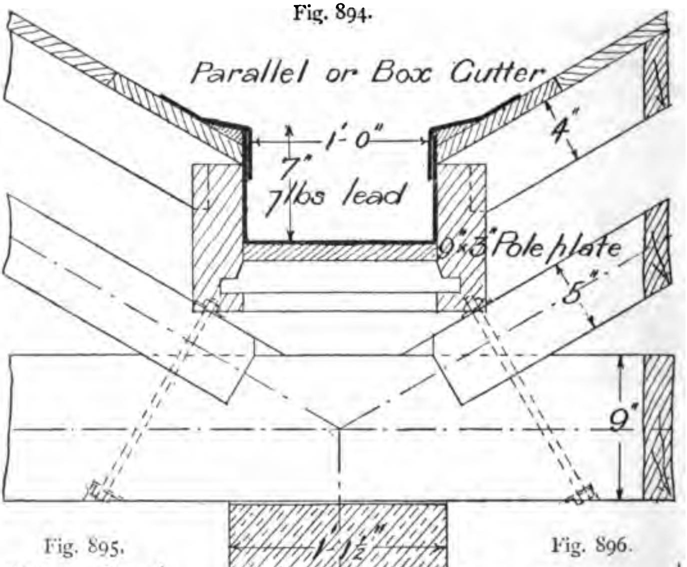


Fig. 895.

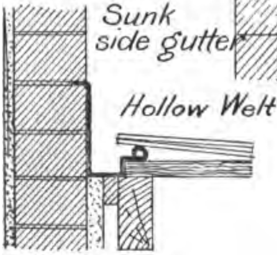
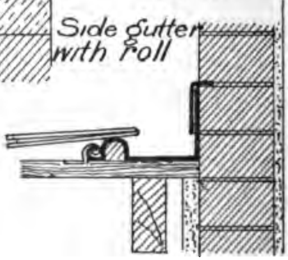
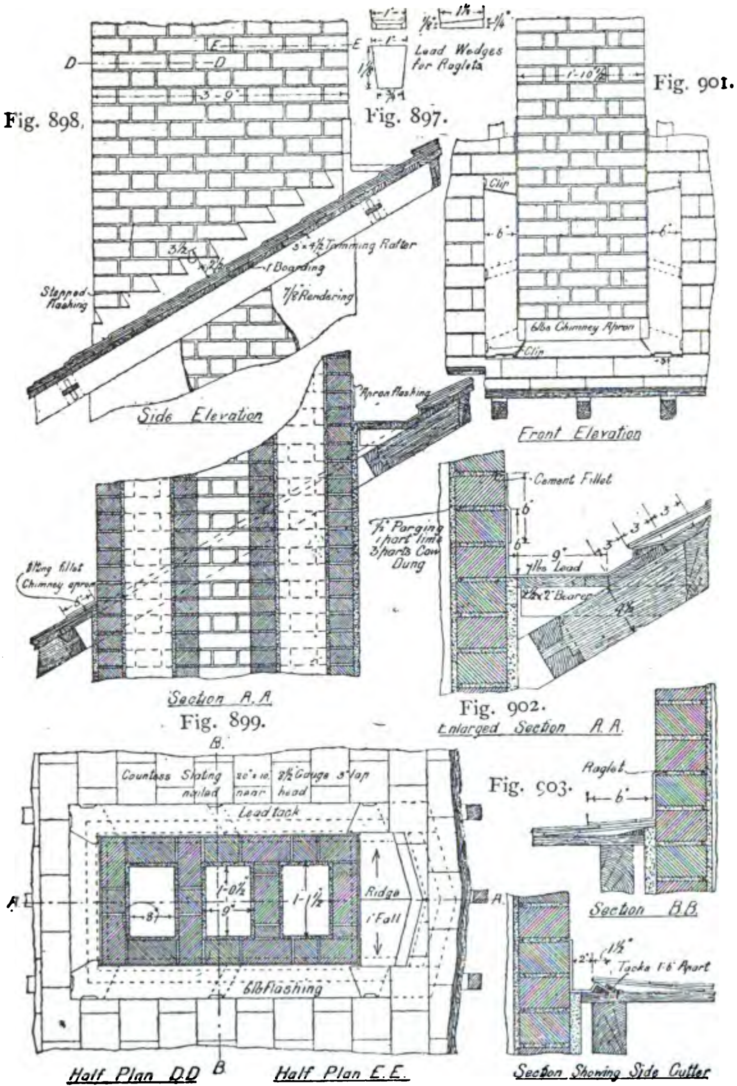


Fig. 896.



Figs. 892–896. Gutters.



Figs. 897-904. Details of Flashings for Chimneys.

Flashings for Chimney Stacks.—Figures 897 to 904 show the mode of preventing any leakage through the joints on the four sides of a chimney stack, at the upper end by means of a gutter, at the sides by fixing stepped flashings or secret gutters, and at the lower end by an apron-piece fixed with lead wedges and tacks, as shown in figures 897 to 901.

Secret Gutters.—When flashings are fixed beneath instead of lying on the slates, secret gutters are constructed, as shown by figure 904.

These secret gutters derive their name from their being hidden from view by the slates. In some situations the slates are carried over the secret gutter so as to nearly touch the wall. This protects the lead from the sun, but the arrangement is bad in any position where leaves of trees or any rubbish might drift into and choke the gutter. To obviate this, the gutter is constructed as shown in figure 904, where the tilting piece forms the depth of the trough, and the edge of the lead under the slates is bent to form a small hollow welt to guide away any water that might pass over the fillet.

Figure 895 shows the boarding cut short on the rafters to give depth to the gutter, and a hollow welt is turned on the edge of the lead for the purpose given above. This is better than the method shown in figure 904.

Side Gutters.—Water is often conveyed from the upper gutters of mansard roofs by side gutters, as shown in figure 896. This is better than the ordinary flashing, as with the latter the water when falling over is driven by the wind, splashes about and gets under the flashings.

Soakers.—The intersections of sloping roof surfaces with end gables or penetrating walls are sometimes made weather-tight by pieces of lead termed soakers, fixed parallel to the walls, and resting on the slopes of roofs about 4 inches. They are turned up against the walls from 2 to 3 inches, and a cover stepped or raking flashing is fixed over the turned-up edges. The soakers should be the length of the slates minus the margin, and plus an inch for clipping over the heads of the slates. Figure 906 shows a soaker cut for Countess slates; and figure 905 is an elevation of soakers, fixed with stepped cover flashings over them to prevent the water leaking between the soakers and the wall. This is better than ordinary stepped flashings, as the wind cannot blow the rain between the roof and wall, and neither can the wind get under the edges as when ordinary stepped flashings are used.

Fig. 905.

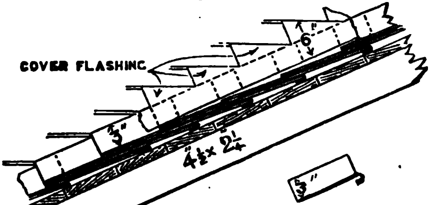
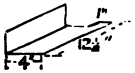


Fig. 906.



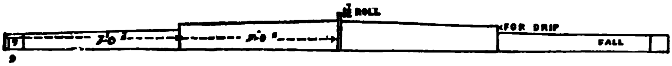


Fig. 907.

In some cases each soaker turns up 6 inches against the wall, and steps are cut and the edges tucked into a raglet, as in ordinary stepped flashing. This is a good plan, but takes a longer time to execute.

Gutters.—Rain water that falls upon roofs naturally runs to the lowest part, and provision must be made to carry the water away. This is done by means of gutters.

Gutters may be either eaves or parapet gutters.

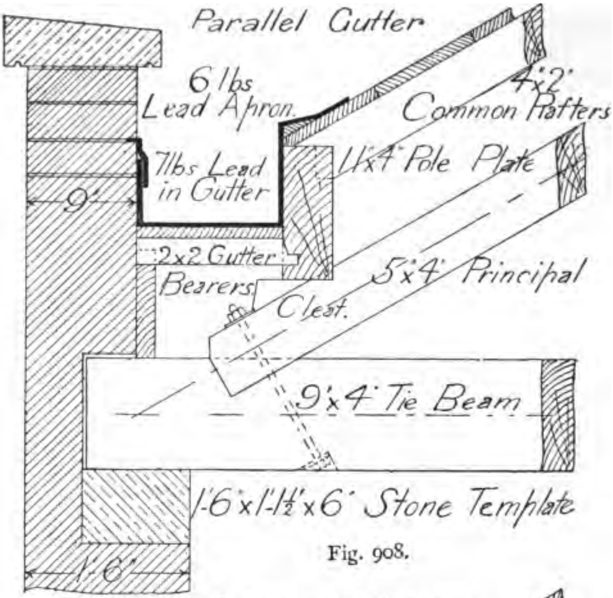


Fig. 908.

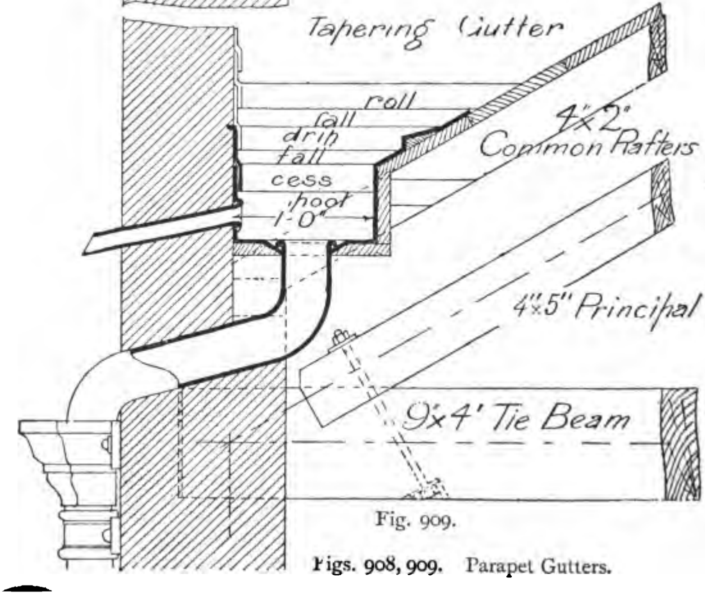


Fig. 909.

Figs. 908, 909. Parapet Gutters.

Eaves gutters consist of small iron troughs, as illustrated in figure 611. In a storm or great downpour of rain they do not, however, accomplish the purpose for which they are intended, and it is not advisable to fix them on that side of a roof which overhangs the public highway. They are usually of cast iron, but should be fixed under the direction of the plumber.

If a roof slopes towards the public highway, it is recommended that a parapet gutter be constructed to guard against slates, tiles, or snow falling into the street.

Parapet Gutters.—Gutters on the outer side of which a parapet wall is constructed are named parapet gutters, and may be parallel or tapering.

Tapering Parapet Gutters.—Parapet gutters are of irregular width when their plans are as shown in figure 907. This suits the construction of roofs where the common rafters rest on the wall plates. Figure 909 shows how to find the required widths of sheet lead at the different positions in the gutters.

Parallel Parapet Gutters.—Roofs constructed with the common rafters resting on a pole-plate fixed some distance away from the parapet, as shown in figure 909, are termed parallel or box gutters. The pole-plate must be sufficiently deep to allow for all necessary falls and drips, which should be the same as when ordinary tapering shaped gutters are used. The timbering for this construction is more expensive than in the ordinary shaped gutters.

Tapering Internal Gutters.—Gutters constructed between the slopes of two adjacent roofs are called internal gutters, and may be tapering when the common rafters of adjoining slopes rest on the same plate. Figure 893 shows a section giving all necessary details for such gutter.

With the exception of the construction of the timber-work, the same section shows a flat sole valley in the slope on an internal angle formed by two roofs intersecting. In this case no drips are required.

Parallel Valley or *Box Gutters.*—When a roof is constructed so that the common rafters of opposite slopes are fixed to separate pole-plates, parallel gutters may be made. If the depth of the gutter is more than 12 inches at the deepest end, it is usual to fix a lead apron, as shown in figure 894, instead of turning the gutters under slates, as in figure 908.

Trough gutters are constructed in **M**-shaped roofs where it is necessary to convey the water from the internal gutter to one of the side gutters by timber troughs lined with lead, as shown in figure 607. They are sometimes mis-called box gutters.

Snow Boards.—These should be provided in all gutters to preserve an uninterrupted channel for draining away the water as the snow melts after a heavy snowstorm. The snow thaws on the underside first, through being in contact with the warm roof; and if the gutters and outlets be choked with frozen snow, that which is thawed will run through the joints in the roofing material. The snow boards as shown in figure 910 consist of a number of strips of wood 2 inches by 1 inch, placed in the gutter with their length parallel to the current of the gutter and spaced about ¾ inch apart; they are supported by and fixed to cross-pieces 4½ inches by 2 inches. From the underside of these bearers a piece at least 2 inches wide is taken out from the centre, and extends to within 3 inches from each end to form an arch for the melted snow to flow through. These are also advantageous on lead flats over which foot traffic passes.

Snow Guards.—These consist of low iron railings fixed at the lower edges of all sloping roofs, for preventing large masses of snow slipping down the roof surface and falling over the eaves; they should be at least one foot high, and the rails should be large enough to thoroughly break the masses. In severe climates on pitched roofs these should never be omitted.

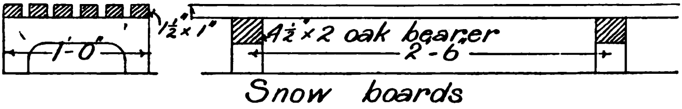


Fig. 910.

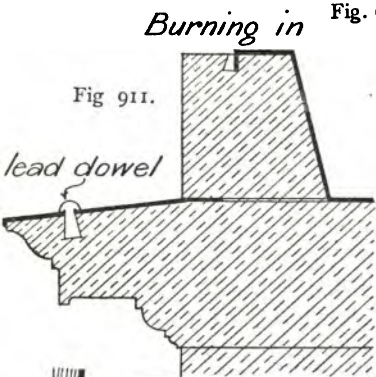
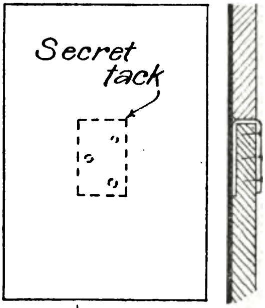


Fig 911.

Fig. 912.



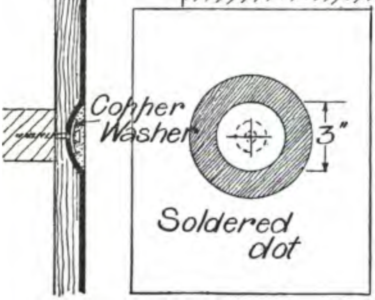


Fig. 913.

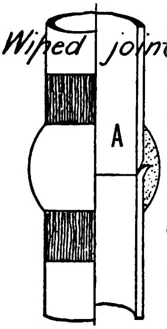


Fig. 914.

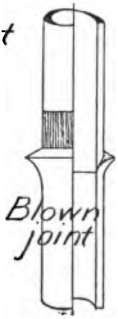


Fig. 915.

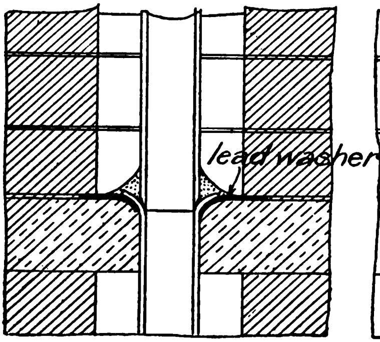
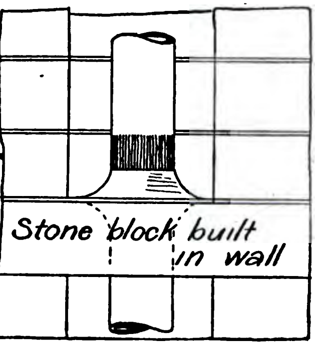


Fig. 916.



Fi . 917.

Burning In.—Lead cover flashings for parapet gutters are sometimes secured to the stone blocking course by being turned into a groove or raglet, cut dovetail shape, on the top or front surface of the stone; molten lead is then poured into the groove which thoroughly secures the flashing to the stonework, as shown in figure 911. As the molten lead shrinks on cooling it is necessary to "set it up," that is to expand the surface with caulking tools or blunt chisels with a rounded end, to fill the groove, and thus ensure the lead being thoroughly secured.

Soldered Dots.—Where large vertical surfaces have to be covered with lead, as on dormer cheeks, they are sometimes secured in the following manner:—Round hollowings, 3 inches in diameter, are dished out of the boards, the lead is dressed into these hollowings and screwed to the boards and studs (the latter are best for screwing to if they come in the required positions). A tinned copper washer should be placed under the head of the screw to distribute the fixing over a greater surface of lead, so that when shrinkage or expansion takes place, the lead shall not be torn by the screw. The hollow is encompassed by a ring of soil (which is a composition of size, lamp black and chalk) to prevent the solder from adhering to the flush surface of the lead covering. The hollow is then filled up level with solder, and is then known as a soldered dot. Figure 913 is a section showing the construction. Lead fixed in this manner is liable to crack near the soldered dots.

Secret Tacks.—A better mode of fixing dormer cheeks is shown in figure 912, where a lead tack is soldered to the back side of the lead covering. The loose end of the tack is passed through a slot cut in the boarding, and secured by copper nails on the inside. The tack, or secret tack as it is called, fixes the covering securely, is not so unsightly as is the former method, and allows more freedom for the lead cheek to expand.

Lead Dowel or *Dot.*—Where exposed parts of stone cornices, strings, etc., are covered with sheet lead, the latter should be protected from high winds. The lead should be laid before the wall or blocking course is built, as shown in figure 911, or turned up and built in the mortar joint, if any. Or the lead may be passed through the wall, and turned up on the inner side. If laid after the wall is built, the lead may be dressed against the outer face of the wall and tucked and wedged in a mortar joint that has been raked out to receive it. To prevent the free edge of the flashing being torn up by the wind, circular holes exactly opposite each other are made in the lead and surface of the stone; the edges of the lead round the hole should be turned up slightly. An iron mould with a small hole through the top is held over the hole in the lead and stone, and molten lead poured in to fill up the holes prepared to receive it, and also the cup-shape hollow of the mould. This fixing is called a lead dowel or dot.

Wiped Joint.—The joints of all lead pipes for conveying water under pressure should be wiped, as shown in figure 914. The process of making the joint is as follows:—The end of one piece of pipe is opened, as shown in figure 914, by means of a tan pin (a conical shaped piece of box-wood). The end of the other piece of pipe is rasped to a sharp edge on the internal face. The pipes are then fitted together, care being taken to keep the internal surfaces true. The two ends are covered with soil for about 5 or 6 inches from the extremities, and then scraped bright with a tool called a shave hook for a distance of about 1½ inch. The pipes are then placed together and secured in position; molten solder is then poured on from a ladle and wiped round the joint with a piece of greased cloth. The solder adheres to the part that has been shaved, and forms a sharp line about the pipe at its junction with the soil. The covered end marked A should be tapered in the direction of the current. Plumbers' solder is composed of two parts, by weight, of lead to one of tin.

Taft Joint.—This is an inferior kind of joint, used for connecting lead pipes together, similar to that shown in figure 915.

Blown Joint.—The ends are prepared and fitted, as shown in figure 915, as for the taft joint and secured in position; a little flux, usually resin, is applied to the joint to aid in the fusion of the solder. Stick solder is used, and is melted by means of a blow-pipe flame, the solder only filling up the part of the pipe that has been opened out. This is the usual joint made in composition pipes for gas, these being much lighter in section than lead, and the maximum pressure on such joints is very small.

Block Joint.—Where large pipes are fixed in vertical chases of walls, the following soldered joint is sometimes constructed, and may be made as follows :—The top end of the lower length of pipe is passed through a circular hole, cut in a wood or stone block built in the wall, and the end of the pipe turned over a lead collar, which is placed upon the block. The upper length of the pipe, with the ends prepared, is then arranged in its proper position over the lower one, and the joint soldered, as shown in figures 916 and 917. These joints frequently break round the arris formed by turning the end of the lower pipe over the collar.

CHAPTER XIII

SLATING.

SLATES are used to cover roofs. They are considerably lighter than tiles and are not so absorbent. A good slate absorbs $\frac{1}{200}$ of its dry weight, and an ordinary pressed tile 9 per cent. of its dry weight; consequently the scantlings for a slated roof need not be so large as those for a tiled roof. They may be obtained in the market, of various dimensions as given:—

Dimensions of Slates.

	Inches.
Smalls	12 × 6
Doubles	13 × 7
Ladies (large)	16 × 8
Countesses	20 × 10
Duchesses	24 × 12
Princesses	24 × 14
Empresses	26 × 16
Imperials	30 × 24
Rags	36 × 24
Queens	36 × 24

But the sizes in common practice are as follows:—Duchess slates, 24 inches by 12 inches, for moderately flat roofs of $\frac{1}{6}$ pitch; Countess slates, 20 inches by 10 inches, for roofs of $\frac{1}{4}$ pitch; and Ladies, 16 inches by 8 inches, for roofs of $\frac{1}{3}$ pitch—the practice being the steeper the pitch the smaller the slate, and the more exposed the building the greater the pitch of the roof.

The following terms are used in slaters' work :—

Head	The upper or top edge of slate.
Back	The upper or exposed surface of slate when laid.
Bed	The lower or under surface of a slate.
Tail	The lower or bottom edge of slate.
Margin	The part of each course of slates exposed to view.
Gauge	The distance apart nails have to be inserted on battens or boards; this is required to determine the position of the battens to receive the nails by which the slates are secured.
Bond	Where a joint of two adjacent slates is immediately in the centre of the slate, the tail end of which rests upon them, the slates are said to bond.
Lap	The distance the tail of one slate overlaps the head of second course below, when slates are nailed near the centre, or the distance the tail of slate overlaps the nail-hole of second course below when slates are nailed near the head. The lap in practice ranges from 2½ inches to 4 inches ; in this book it will be taken as 3 inches.
Holing	The piercing of slates to receive nails.
Sorting	Where the roof is to be covered by slates of different lengths, they are regulated to proper dimensions so that the largest slates may be nailed near the eaves, and the smallest at the ridge.
Eaves	The lower part of slating hanging over a wall.

There are two methods of laying slates :—

1st.—By nailing near the head.
2nd.—By nailing near the middle.

The groundwork to receive slates may be prepared in one of the following methods :—

1. *With Wood Battens* nailed horizontally across rafters fixed to the required gauge.

2. *With Close Boarding*—that is, the rafters are boarded over, and the slates nailed direct to the boards; this is a better method than battening.

3. *With Close Boarding and Asphalted Felt.*—The felt is a non-conductor and prevents radiation, and thus preserves a more equable

temperature in the interior of buildings; it is also waterproof, and thus forms an extra precaution against damp.

4. *Close Boarding Felt and Battens.*—Where the slates are laid direct on the felt, the latter is liable to decay from want of ventilation; to prevent this, battens are laid horizontally on the felt to which the slates are fixed, thus allowing a circulation of air over the surface of the felt.

5. *Close Boarding, Felt, Vertical and Horizontal Battens.*—The last method is open to the objection that should any water find its way between the slates, as in the case of a broken slate, the water would lodge upon the horizontal battens and cause them to rot. To avoid this, battens are first laid on the felt to the slope of the roof, and fixed one over each rafter; horizontal battens are nailed to these again, and then the slates, so that should any water get beneath the slates it can run away. This leaves a larger air space, which is better for ventilating the battens and felt, also for preserving the temperature inside the building. This method should be adopted on all monumental buildings, and on roofs not easily accessible.

Gauge for Nailing Slates near the Head.—In this method of fixing slates, the nail holes are placed one inch from the head. The calculations to ascertain the gauge are as follows:—One inch plus the lap is deducted from the total length of the slate, the first being due to the material above the nail-hole not being included in the lap, and the remainder is divided by two, which will give the gauge, and may be stated thus:—

$$\text{Gauge} = \frac{\text{length of slate} - 1'' - \text{lap}}{2}, \text{ which}$$

In Duchess Slates would be $\frac{24 - 1 - 3}{2} = \frac{20}{2} = 10$ inches.

„ Countess „ „ $\frac{20 - 1 - 3}{2} = \frac{16}{2} = 8$ „

„ Ladies „ „ $\frac{16 - 1 - 3}{2} = \frac{12}{2} = 6$ „

Figure 918 shows slates fixed by this method.

Gauge for Fixing Slates near the Middle.—The gauge is determined as follows:—The lap is deducted from the length,

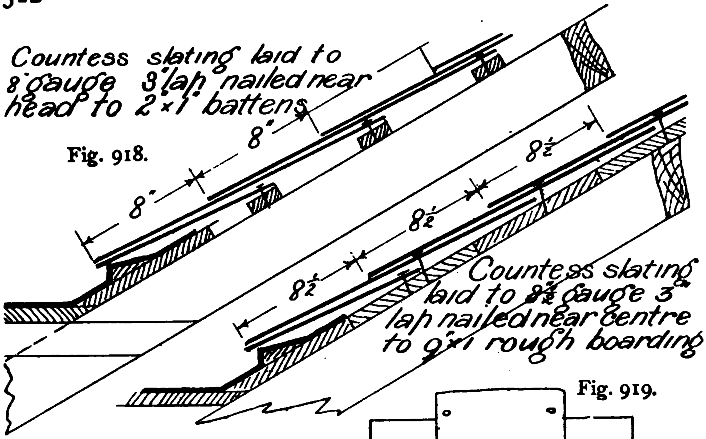

Countess slating laid to 8" gauge 3" lap nailed near head to 2"×1" battens
8"
8"
8"
8½
8½
8½
Countess slating laid to 8½" gauge 3" lap nailed near centre to 9"×1" rough boarding

Fig. 918.

Fig. 919.

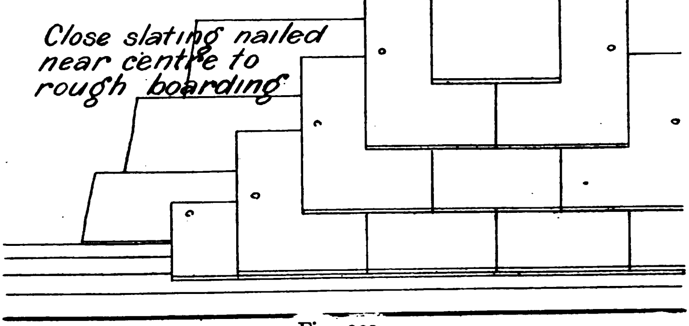


Fig. 920.

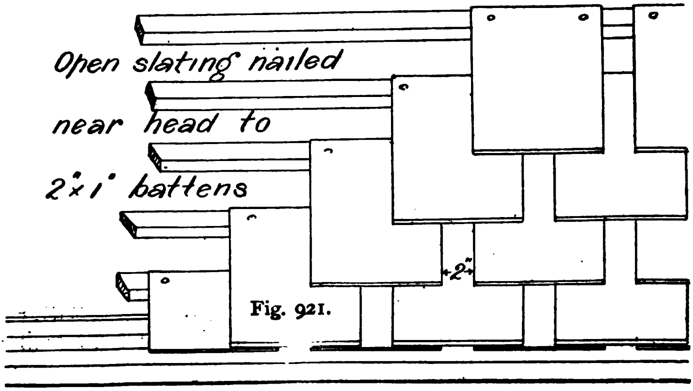


Fig. 921.

and the remainder is divided by 2, and may be stated thus:—

$$\frac{\text{Length of slate} - \text{lap}}{2}$$

In Duchesses would be $\frac{24-3}{2} = 10\frac{1}{2}''$.
,, Countesses ,, $\frac{20-3}{2} = 8\frac{1}{2}''$.
,, Ladies ,, $\frac{16-3}{2} = 6\frac{1}{2}''$.

Figure 919 shows slates fixed by this method.

The slater determines the position of the nail-hole in the following manner: the lap is added to the gauge, and ½ inch for clearance is allowed—measurements being taken from the tail. It may be stated thus:—

Gauge + lap + ½" = distance of nail-hole from tail—
In Duchesses would be $10\frac{1}{2} + 3 + \frac{1}{2} = 14''$.
,, Countesses ,, $8\frac{1}{2} + 3 + \frac{1}{2} = 12''$.
,, Ladies ,, $6\frac{1}{2} + 3 + \frac{1}{2} = 10''$.

The distance of nail-holes from the long edges in either method is 1¼ inch.

It can thus be observed that fewer slates will be required to cover equal areas of similar roofs by the method of nailing near the middle, than by the method of nailing near the head.

Advantages and Disadvantages—Of the two methods—are as follows:—Slates that are nailed near the head always have two thicknesses of slate over every nail-hole, and the lap is practically 1 inch more than that which is calculated if the portion above nail-holes is taken into account. But as this method requires more slates, it is therefore more expensive; and the long distance the nails are fixed from the tail allows the wind to act with a greater leverage, which, in bad weather, sometimes strips the roof.

Open Slating.—Slates are sometimes laid so that the adjoining slates of the same course are a distance apart, about 2 inches, as in figure 921. A roof covered in this manner would not require nearly as many slates as the former methods; it is largely used for sheds and temporary buildings.

Doubling Eaves Course.—Slates are laid commencing at the eaves; the length of the slates should be as follows:—Gauge + lap + 1 inch in slates nailed near the head. In Countess slates this would be 8 + 3 + 1 = 12 inches, and nail-hole would be 11 inches from tail, as shown in figure 918. Where slates are nailed near the centre, gauge + lap is the length; this would be in Countess slates 8½ + 3 = 11½ inches, and the nail-hole would be at the centre of tilting piece, but if the tilting piece is covered with lead, the nail-holes would be made near the head, as shown in figure 919.

Smooth Side of Slates.—Slates have one side smoother than the other, and a slater, in cutting on the smooth side, obtains a sharp edge, but on the rough side it is jagged. The doubling eaves course is laid with its smooth side up, the course above and all succeeding courses are laid with their smooth side down, so as to obtain a close joint to guide away the rain and wind.

Lead and Copper Tacks.—These are used for repairing defective slated roofs, the method being as follows:—The broken slates are removed, the nails being cut or drawn by a tool called a ripper, which has a thin blade about 2 feet long and 1 inch wide, being about 2 inches broad at the end, with a notch each side to receive nail; the tack is then hooked over the head of the slate below, the new slate is inserted, and the lead clip turned up over the tail. Two tacks should be used to each slate.

These lead or copper hooks are usually about ½″ wide, the distance between the hooked ends being equal to the length of the slate minus a gauge.

Tilting Fillets.—To enable the tails of slates to fit closely against the slates below, and to form a close joint to keep out wind and wet, a tilting fillet or springing piece, as it is sometimes called, must be nailed under the tail of the first slate or doubling course. This will give all the slates a tilt, and cause them to bend on their tails. The slates will consequently be slightly apart, the less the distance apart the better, so that, during repairs, they may be less likely to be broken. The tilting pieces are about ½ to ¾ inch thick, and tapered, as in section figure 918.

When roofs are battened, instead of a separate tilting piece, the first batten may be 1¼ to 1½ inch thick, and tapered.

Tilting fillets are also used against chimney breasts, to guide water away from walls, as in section figure 899, or at ridge, to compensate for the tilt of slate lost by its length being shorter than others, as in section figure 924, or in any position where slates are desired to be slightly raised.

Tails of Slates.—Slates should be laid with their tails horizontal, but wherever taper-shaped gutters occur in roofs the side of the gutter nearest the ridge is not parallel with it, as shown in plan, figure 907. So the tails of doubling courses form an exception to this rule.

Slate Hips and Ridges are now much used in the place of lead to save expense. The slate ridges are holed and bedded in hair mortar, the holes filled with white lead and secured with copper screws, and the adjoining pieces dowelled together with small slate dowels, as shown in figure 924.

Stone Slab Roof Covering.—Stone slabs generally from

½″ to 1″ in thickness, and of dimensions up to 2′ 0″ square, are used for the coverings of roofs, being very durable and give a pleasing effect.

Fig. 922.

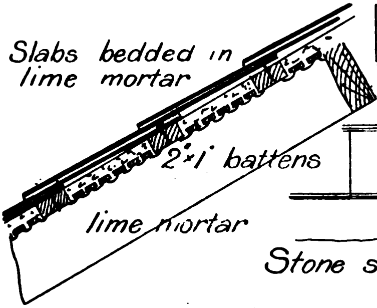
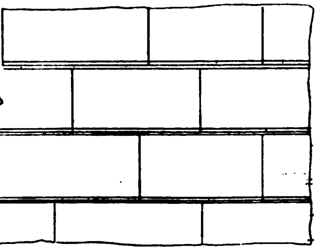


Fig. 923.



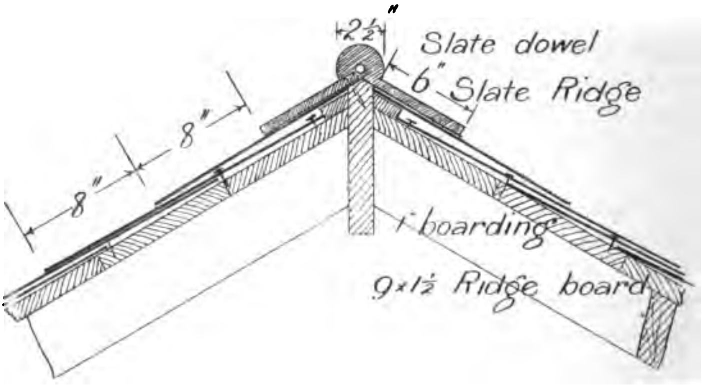


Fig. 924.

They are quarried in various sizes, after which they are sorted in lengths, as all slabs laid in the same course are of the same length and where possible of the same width. The larger slabs are placed in the courses nearer the eaves, and the courses are usually set out to diminish as they approach the ridge.

Stone slabs may be obtained suitable for roofing purposes from Collyweston, near Stamford, Naunton in Gloucestershire and Stonefield, Oxfordshire.

Taking the Collyweston slabs as typical, they are laid as follows:—

The battens are fixed longitudinally to the common rafters, the necessary diminishing gauge having first been determined by the size of the material to be used. The spaces between the battens are then lathed and filled in solid with ordinary lime mortar brought up flush with the battens. The slabs are then fixed in position by nailing near the head with one galvanized iron nail, having previously been bedded on stone lime mortar and pointed with the same material. The stone lime is prepared from an upper layer of stone from the same quarry as the slabs.

The slabs are cut and mitred at hips and valleys, and finished with lead in a manner similar to ordinary slating.

The slabs on being tested for absorption are found to collect little more than an average roofing tile. Stone slabs usually absorb about $\frac{1}{12}$ of their weight.

This method of roof covering has been used at the Indian Institute, Oxford, and on many of the modern buildings of Oxford and at the Henley New Town Hall.

Figures 922 and 923 show a part section and part elevation of slabs laid by this method.

Nails.—Slating nails have flat circular heads, have a sharp point on shank, and are made from 1¼″ to 2″ long. The five following materials are in general use for the manufacture of nails, viz., iron, zinc, copper, composition and lead.

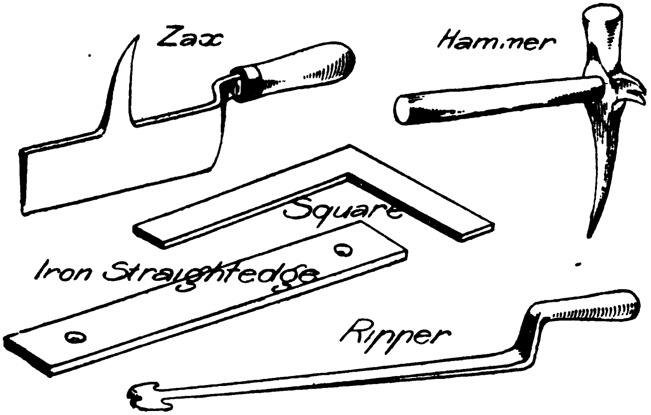
(1) *Iron* nails may be either cast or malleable. The cast resist oxidation better than the malleable, but being brittle are inferior to the above, and are only used for cheap work. Malleable nails are first cast and then made malleable; they are often galvanized or painted to resist oxidation, but they are better when dipped while hot into boiled linseed oil, which method is frequently and successfully adopted.

(2). *Zinc* nails are very soft and easily broken; they are not well adapted for driving, and are therefore wasteful and expensive to use.

(3). *Copper.*—These may be obtained as wrought or cast, are very soft, expensive, and are not much used.

(4). *Composition.*—These are a mixture of zinc, copper and tin. The alloy is much harder than either the copper or the zinc; does not oxidise to any extent, and is better adapted for driving. They should be employed on all important work.

(5). *Lead.*—These, as shown in figure 530, are similar to the ordinary slating nails, and about 4 inches in length. They are used for securing slates direct to iron battens. The nail is passed through the hole, and is bent about the small tee or angle iron batten. They are much used for boiler houses and similar work, where a great measure of fire resistance is of more consequence than appearance.



Figs. 925—929.

Specification of Slates.—The whole of the slates to be of the best quality, properly squared, free from spots, and of such quarries and colour as shall be approved by the architect. Each slate, when nails are used, to be holed near the centre of its length (or near the head) and secured with two strong nails for each slate, the third slate to overlap the first not less than 3 inches, and to bed flat upon the previous course. Upright slating to have 4-inch laps and be fixed to walls with four nails each.

In all descriptions of roof slating the eaves to be a double course of slates, the under course being cut to the required length.

The nails for Countess and Duchess slates to be not less than 1½ inch long, and for larger slates to be not less than 2 inches long.

If iron nails are used they are to be dipped while hot into boiled linseed oil.

Slater's Tools —The principal tools distinctively used by the slater are the zax, iron straightedge, hammer, and ripper, as shown in figures 925 to 929.

(1). *The zax* is used for trimming the edges and holing the slates.

(2). *The iron straightedge* is used for trimming slates, and is fixed to the edge of the bench or block by means of screws or sharp iron points projecting from the underside.

(3). *The hammer* with hammer face at one end, and sharp point at other for holing, with a projection from side with slot for drawing nails.

(4). *The ripper* is a thin steel blade about 2 feet in length, provided with a handle; the other extremity is flattened out to a semicircular shape and has three slots as shown in figure 929; it is used for removing broken slates, the nails being cut by the slotted semicircular end.

In addition to the above the slate mason is provided with squares, saws, mallets, and chisels similar to other masons.

CHAPTER XIV.

BUILDING QUANTITIES AND MEMORANDA.

Necessary knowledge.—To be able successfully to take off quantities from drawings, and prepare estimates preparatory to pricing, three things are necessary—first, a thorough knowledge of arithmetic and mensuration; secondly, a sound knowledge of the details of building construction in all trades; thirdly, practical experience in the application of the two foregoing qualifications, to take off the measurements and state them in the manner usually adopted and understood.

The detailed dimensions are first of all "*taken off*" the drawing, and written down in columns, in the order of the length, breadth and depth, with an abbreviated description of the work to which the dimensions refer. When this has been done for all trades, the next operation is "*squaring the dimensions*," to obtain either the cubic or superficial measurements resulting from each set of dimensions. These results are collected together in the "*abstract*" for each trade; the total "*collections*" in each abstract are then placed in their proper order in a "bill of quantities;" the bill is ruled so that a price and a total may be placed against each item; the sum of all the totals will give the total proposed cost of all the work mentioned and described in the bill of quantities. This is termed the "*estimate*."

The student will not be able to proceed far without knowing the usual methods adopted for measuring the various kinds of builders' work, both labour and material, and the proper descriptions to be placed in the bill; the following are some general notes relating to this matter, under the proper trade headings.

EXCAVATORS' WORK.

General digging, at per yard cube. Beyond 6 feet deep, keep separate and divide into stages of 6 feet each; wheeling over 20 yards keep separate, and divide into runs of 20 yards each; basketing out, keep separate, if no concrete take digging 6 inches wider than base of footings; describe if dig and cart away; dig, wheel, and spread, or if dig and part fill in and ram. In trenches the space occupied by the concrete and wall is dig and cart or dig, wheel, and spread. The remaining space is dig, fill in, and ram.

Concrete at per yard cube generally; if under 12 inches deep, at per yard superficial. State proportions of materials to be used, if in lime or cement, &c.

Wells, at per yard cube, stating diameter, depth, distance to be removed and description of soil.

Surface digging, at per yard superficial, if 12 inches deep or under.

Spread and level, at per yard superficial, with description of average depth.

Hard brick rubbish, at per yard superficial, if 12 inches deep or under; above, at per yard cube.

Clay puddle at per yard super, describing thickness.

Shoring, strutting, and planking at per foot super, to *trenches* under 6 feet wide at per foot run.

Drains at per foot run, to include digging, laying, jointing, concreting, filling, and ramming. Take a running dimension over all pipes and connection. When the latter are taken they are charged as extra only upon the cost of this item. State size of pipe, with description, how jointed and enclosed, and the average depth of the trench.

Lengths of drain upon which there is any additional labour should be kept separate and so described, such as "deep digging," "tunnelling," "strutting to trench," &c.

Bends, junctions, traps and gulleys are numbered, and having been measured in the length of the drain are described as "extra only" upon the cost of the drain.

Manholes are numbered and described.

Piles are numbered. State size and description of timber and length to be driven.

Number the rings, shoes, pointing, and cutting off heads when driven; state weight of ironwork.

Memoranda.—The following is the ratio of the increase in bulk of the undermentioned earths when excavated:—

Earth and clay	about	¼
Sand and gravel	„	$\frac{1}{12}$
Chalk	„	⅓ to ½
Rock	„	½ to ⅘

In the mixing of concrete, the final bulk is about ⅔ of the volume of dry materials before mixing; for instance, a cubic yard of concrete *in situ* requires about 1½ cubic yards of cement, gravel and sand.

BRICKLAYERS' WORK.

Brickwork, where used in large masses as for engineering works, is sometimes measured per foot cube. The usual London method is as below:—

The following is measured superficially:

Brickwork in mortar, at per rod of 272 superficial feet, 1½ brick thick, all thicknesses to be reduced to this standard.

All half-brick walls are measured similarly but priced separately.

Brickwork in cement, measured as above, but usually included in the brickwork in mortar, and described again separately as "*Extra only in cement.*"

Keep all above 5 feet from the ground separate, also all built-in small pieces.

Facings are measured at per foot superficial, as "*extra only*" upon the cost of the general brickwork; allow 3 inches below the ground and 3 inches at junction of roof with gable wall.

Fair face and point, at per yard superficial, where the same kind of bricks are used in face and body of wall.

Fair and rough cutting all over 6 inches wide at per foot superficial.

Damp course at per foot superficial.

Arches in walls in lime mortar are measured in with the ordinary brickwork. Rough arches in cement, axed or gauged arches, are described and charged as "*extra only*" upon common brickwork, all extra necessary labour and material above those required in the common brickwork are charged for in all arches, such as fair or rough cutting, turning pieces, &c.

Trimmer arches and vaulting at per foot super, describing and stating thickness.

The following work is all measured by the superficial yard:—Brick-paving, brick-nogging, rough rendering, cement floated face, cement or tar paving, asphalte-paving, and tiling on brick.

The following is measured per foot run:—

Fair and rough cutting, if under 6 inches wide.

Birdsmouth, squint quoin, cutting and pinning.

Chase for pipes, cutting, toothing, splays, chamfers.

Cement fillet, lime and hair filleting, joints of groined arches, rake and point flashings.

All the following to be numbered, with a proper description:—

Mitres and stopped ends to cornices, strings, &c., bedding and pointing door and window frames; flues, parge, and core, stating average length; ends of sills cut and pinned, holes cut for pipes, coppers, and setting; all stoves and setting; chimney pieces and fixing; brick seatings to w.c. traps, trimmer arches levelled up for hearths, rendering chimney backs in cement, air bricks and fixing.

Memoranda.—To reduce cubic feet of brickwork to rods, 1½ brick thick, deduct ⅑th, and divide by 272.

Facings require about 7 bricks per foot superficial, a rod of brickwork with a ⅜″ joint requires 4,356 bricks and 3 1/30 cubic yards of mortar. Allowing for waste and consolidation this will mean 4,500 bricks, 1½ yard of chalk lime, and 3 yards of sand, or 4,500 bricks, 1 yard of stone lime, and 3½ yards of sand, or 36 bushels of cement and 36 of sand to bricks as before, or 30 bushels of blue lias lime to 60 bushels of sand. A ton of Portland cement is 11 sacks. There are 21·09 striked bushels to 1 yard, 30 bushels of lump lime to 1 ton of quicklime, 26·6 bushels of ground lime to 1 ton of quicklime.

In the mixing of lime and cement mortars of the usual proportions the final volume may be taken as about ⅔rds of the volume of the dry materials before mixing, as may be deduced from the quantities for 3 1/30 cubic yards of mortar required for a rod of brickwork.

A striked bushel = 1·28 cubic feet, therefore a cubic yard = 21·09 striked bushels.

MASONS' WORK.

Take all stone at per foot cube including hoisting and setting. If the hoisting is over 40 feet in height, take an extra to, and divide into heights of 20 feet, as 40′ to 60′, 60′ to 80′, &c.

All labours to be taken separately and be measured at per foot super. The final labours include all preparatory labours:—

Half sawing or half-plain.—This labour is taken to all faces upon which no other labour is taken, such as the back of ashlar work, the back of a cornice, &c.

Half-plain work.—This labour is taken to beds and joints; each of the two worked surfaces to each joint is paid for as half plain work.

Plain face.—This labour is taken to all exposed plain surfaces upon which no further labour is placed.

Plain work to beds and joints.—Sometimes taken in London, the area of the joint made up by the two worked surfaces in contact being measured as the area of one of the surfaces in lieu of being taken as half-plain work to the two surfaces in contact.

Sunk beds and joints.—Taken in all cases where the face of the bed or joint is sunk below the general face.

Sunk face.—In all cases where the face of the work is sunk back or recessed, and the surface is equal to plain work.

Moulded work.—All mouldings where the girth exceeds 6 inches.

Circular face; circular sunk face; circular moulded face.—When the work is circular on plan as well as circular on face, the work is described as *circular circular.*

Pavings.—Measured with description.

Landings, treads and risers, hearths, shelves, large tem plates, and cover-stones over girders.

The follwoing labours are measured at per foot run:—

Moulded work, under 6 inches girth, rebate and chamfer, joggle joint, groove, throating.

The following at per foot run will include both labour and material:—

Curbs, steps, window-sills, and thresholds, not exceeding 18″ × 6″ in section.

The following items are numbered:—

Stopped ends and mitres to mouldings, splays, chamfers, &c., with proper description; mortices, dowels, lead plugs circular perforations, holes for pipes, cramps for copings, sinks, gully stones, chimney pieces, small templates, corbels.

STONE WALLING.

Rubble work is measured at per foot cube to walls 2 feet or above in thickness. Walls less than 2 feet in thickness are kept separately and their thicknesses stated.

The extra labours on face work should be taken separately.

SLATING.

Slating.—This is measured by the square of 100 feet superficial; allow the length × 6″ for all straight cuttings and × 12″ for circular cuttings, the length × 6″ to each side of hips and valleys; allow the length × half the length of the slates used for the double course at eaves. Allow 6″ for verges.

Circular and conical work to be kept separate.

Slate in thicknesses is measured at per foot superficial, the labours upon some being measured separately.

Slate cisterns, lavatory tops, chimney pieces, &c., are usually numbered with a description.

The slater purchases slates, obtaining 1,200 for every 1,000 invoiced.

Slaters' memoranda.—

Ladies.—16″ × 8″ × 6½″ gauge nailed near head, 278 to cover a square of 100 feet super.

Countesses.—20″ × 10″ × 8½″ gauge nailed near head, 170 to cover a square of 100 feet super.

Duchesses.—24″ × 12″ × 10½″ gauge nailed near head, 115 to cover a square of 100 feet super.

Each slate requires two nails, 1⅜″, 1½″, 1¾″ long respectively, for the above dimensions. To the above quantities it is usual to allow $\frac{1}{20}$th for cutting and waste.

TILING.

Plain Tiling is measured at per square of 100 feet superficial; allow the length × 6″ for all straight cuttings, × 12″ for all circular cuttings. Allow the length × 6″ for eaves also to each side of hips and valleys. Allow 6″ for verges.

Measure at per foot run for ridges, hips, or valley tiles, bedding eaves in cement, filleting in cement.

Number apex tiles, hip hooks.

Tiles fixed vertically should be kept separate and the gauge described. Circular tiling to be kept separate and described. Where the pitches of intersecting slopes vary, attention must be called to the different gauges necessary if special valley or hip tiles be used.

Pan Tiling.—Allow the length × 12" for cuttings to each side of hips and valleys, in other respects measured similarly to plain tiling. The tiler purchases tiles, obtaining the exact number per thousand, no allowance being made as is done for slates.

Tilers' memoranda.—Hurst's Handbook :—

A plain tile measures 10½" × 6½" × ½", and weighs about 2½ lbs.

A pan tile measures 13½" × 9½" × ½", and weighs about 5¼ lbs.

Tiling requires—

Per square of 100′ super 4" gauge 600 plain tiles.
„ „ „ 3½" „ 700 „ „
„ „ „ 3" „ 800 „ „
„ „ „ 10" „ 180 pan tiles.
„ „ „ 11" „ 164 „ „
„ „ „ 12" „ 150 „ „

A square of plain tiling weighs on the average 15 cwts.
„ „ pan „ „ „ 8 „

A plain tile lath is 1" wide and ¼" thick.
A pan „ 1½" „ 1" „

100 plain tile laths 5′ long equal 1 bundle.
12 pan „ 10 „ „ 1 „

1 bundle of laths, 1½ cwt. of nails, 1 peck of tile pins, 3 hods of mortar } to 1 square of plain tiling.

1 bundle of laths, 1¼ cwt. of nails } to 1 square of pan tiling.

CARPENTERS' WORK.

Keep separate, placing the least expensive first, the different kinds of wood, such as fir, pitch pine, oak, teak, &c.

The following is taken at per foot cube:—

Fir rough and fixed in plates, lintels, and wood bricks.

Fir rough and fixed in ground joists and sleepers.

Fir rough and fixed in floors.

Fir rough framed and fixed in floors.

Fir rough and fixed or rough framed and fixed in girders.

Fir framed in roofs and in roof trusses.

Fir framed in stud partitions, and fir framed in trussed partitions.

Oak in templates. Oak in curbs.

All work is considered as framed where it is necessary to use chisels in forming the joints. Allow 6″ for laps, for the number of laps determine the value of n when $(n - 1)$ 16 feet equals the joined length of fir plates and $(n - 1)$ 12 feet joined length of oak plates. Allow for each scarf three times the depth of the timbers lengthened, and for the number of scarfs the value of n when $(n - 1)$ 15 feet equals the length of the scarfed timbers.

The following work is measured at per square of 100 *feet superficial:—*

Boarding to roofs and flats, and including firring to the latter.

Battening for slates or tiles. Wall battening, stating distance apart and including plugging.

Weather boarding, sound boarding, centering to vaults, &c.

The following work is measured at per foot superficial:—

Gutter boards and bearers.

Eaves boards, valley boards.

Centering to trimmers and apertures.

Bracketing for cornices, cradling for entablatures, girting the faces of the two latter items.

Measure the following work at per foot run:—

Mouldings, rebates, grooves, featheredge springing pieces, herring-bone strutting, tilting fillet, turning pieces to arches, 4½″ soffit, deal rolls for flats.

The length of all scantlings in lineal measured work or reduced to superficial or cubic measures, when measured in detail, to be taken at the extreme points, including tenons and scarfs. The length of a scarfed joint, unless shown specifically, to be taken as three times the depth of the pieces joined.

Number the following and describe:—Cleats, shaping ends of rafters, rebated drips in gutters, cesspools, extra to angle brackets, extra to fixing ironwork to trusses.

Buying of Timber.—Pine and spruce timber is sold by the standard hundred, the load, or by the square of 100 feet super. There are several standard hundreds in use, as follows:—

London ...	120	pieces	12	feet	long	9 in.	by	3 in.
Petersburg ...	120	,,	6	,,	,,	11 ,,	,,	3 ,,
Christiania ...	120	,,	11	,,	,,	9 ,,	,,	1¼ ,,

The Petersburg standard is the one most generally followed, and equals 165 feet cube; a load of timber is 50 cubic feet (hewn), so that there will be $3\frac{8}{10}$ loads in a standard. It will simplify calculation to commit to memory one or two facts relating to these measurements:—165 feet cube is 165 feet run of 12 in. × 12 in.

In dealing with a scantling of 12 in. × 4 in., its section is one-third of the 12 in. × 12 in., so that to make up a standard in that scantling it would require 165 × 3 = 495 feet run.

The price per foot run can be obtained in this way if the value of a standard is known, the cost of cutting being added.

Classification of timber according to size:—

	in.		in.		in.		in.
Balk	12	by	12	to	18	by	18
Whole Timber	9	,,	9	,,	15	,,	15
Half	9	,,	4½	,,	18	,,	9
Scantling	6	,,	4	,,	12	,,	12
Quartering	2	,,	2	,,	6	,,	6
Planks	11	to	18	by	3	to	6
Deals			9	,,	2	,,	4½
Battens	4½	,,	7	,,	¾	,,	3
Strips and Laths... ...	4	,,	4½	,,	½	,,	1½

Pieces larger than planks, generally called timber; but sawn all round, called scantling; when equal dimensions, called die square.

JOINERY.

Joinery, including material, is measured by the foot superficial or foot run and special labours are numbered.

The following items are measured by the foot superficial:—

Skylights, Sashes and Cased Frames with detailed description, any extra labours to be measured as they occur.

Window linings and boards, backs, elbows and soffits, jamb linings, spandril linings, outside shutters, boxing shutters, lifting shutters, doors and gates, framings, w.c. fittings, bath fittings, cisterns and sinks, sashes in solid frames.

Staircase work—treads and risers, wall strings, apron linings, outer strings.

Floors are measured by the square of 100 feet superficial. Allow a dimension of 3″ for all raking cuttings, keep separate all small pieces, and describe as including bearers.

For all superficial dimensions, such as doors, windows, &c., the tenons are to be included in the price of the superficial quantity when put together and fixed complete.

One-sixteenth of an inch to be allowed on the several denominated thicknesses of superficial work for each wrought face.

In work measured superficially, the separation in the measurement and value of all work consisting of partly straight and partly curved, such as segmental sash frames and sashes, is to be made precisely at the springing or commencement of the curve, taking the extreme height by the extreme width, each division net and the prices to include all materials and labour.

The same method is to be observed in dividing curved parts from such as are wreathed, groined from straight parts of centering, cradling, &c.

The following items are measured at per foot run:—

Grounds at per foot run. If over 3 inches wide, take at per foot superficial, and describe labours on same.

Skirtings, including backings, with description; also scribings of floors and skirtings.

Handrails, balusters (including tenons), deal cornices, and architraves, noses to landings, window nosings, capping to gates, mouldings: extra labours as they occur.

In work measured lineally, such as solid door frames, when the head is circular, keep separate and describe.

The following items are numbered:—Tongued and mitred angles, housings, returned ends, &c.

On account of the number of items in joiners' work, the work usually numbered is placed in connection with the leading item to which it refers. For example, all the extra labours numbered on skirtings would follow after the item for skirting instead of being placed at the end of the bill together.

IRONMONGERY.

It is important to state if "*screws and fixing*" are to be included.

Hinges.—Measure the length along the knuckle for butts or back flaps; or from knuckle to point for cross-garnet hinges. All patent hinges according to description.

Bolts.—Measure length of the rod of bolt and describe.

Locks.—Measure length and describe; take sets of furniture separately. Cupboard locks are measured by their height, not length; take finger plates separately.

Separate all brass work and describe; any provisions should state if prime cost or to include fixing.

SMITH AND FOUNDER.

The following items are measured and reduced to weight:—

All heavy cast and wrought constructional iron work; measure all labours on the iron separately, such as drilling, planing, fitting, &c.

In riveted work an allowance must be made for weight of rivet heads, usually 5 per cent. added on in ordinary riveted girders.

Describe any necessary labour in the hoisting of constructional work.

Chimney and bearing bars measure at per foot run, and bring to cwts.; straps and bolts measure at per foot run, and bring to cwts.; also saddle bars, guard bars.

Flitch plates at per foot superficial, and bring to weight in cwts.

Hand rails and balusters are measured at per foot run, and brought to weight; describe if "*framed.*" Circular and wreathed work keep separate.

The following items are measured per foot run:—

Eaves gutters measured over all, and charge as *extra to* for all outlets, angles, stopped ends, mitred ends, &c.

Rain-water pipes measured over all, and charge shoes, bends, heads, &c., separately.

Railings wrought and cast. Gates taken separately.

The following items are numbered:—

Grates, ranges, sets of copper fittings, soot doors, ventilators, manhole covers, and all patterns for cast-iron work.

PLUMBERS' WORK.

Sheet lead is measured by the foot superficial, and brought to weight.

The following allowances must be taken into account:—

For 1½" drips—6" in length.

For 2" drips—8" in length. The same for rolls.

Flashings, add 6" for every angle, and about ½" for every foot allowance for tacks. Allow for each passing 4".

Ridges allow as for flashings, and about 18" wide; valleys and hips are taken rather wider.

Allow a width of 12" for stepped flashings, with same allowances as for straight flashings.

Soakers may be taken the length of slate minus the length of the margin of the slate, by a width of 6 inches.

The following are taken at per foot run:—

Lead or oak wedging to flashings.

Copper nailing, welted edge, burning in, serrated edges, and labour to secret gutter.

Lead pipes at per lineal yard, stating weight. State if including all soldered joints, tacks, wall hooks, &c.

Number all branch joints, soldered ends.

Bath and w.c. fittings are described, care being taken to specify what labours are to be included, and what are taken separately in other parts of the bill.

GAS FITTING, BELLHANGING, AND ELECTRIC LIGHTING.

Gas Fitting.—Measure by the foot run over all, describing material and diameter; opening of ground, stating depth and filling in, numbering and taking extra only for all connections, bends, elbows, tee pieces, &c.

Number all perforations and making good, brackets, pendants, and all fittings, for which allow a provisional amount, or select from manufacturer's list and state catalogue number.

Hot-Water Pipe and Fittings.—Measured similarly to gas fitting.

Bellhanger.—Number all bells, pulls, and cranks. Allow a provisional amount, or quote manufacturer's list, bell boards painted complete.

Copper wire by weight, describing gauge.

Zinc tubing per foot run.

Electric Bells.—Measure by the lineal yard wiring, tubing, and casing.

Number the pushes, bells, fittings, indicators, batteries, &c., with description of same.

Allow provisional amount for perforations and making good.

Electric Lighting.—Measure by the lineal yard wiring, tubing, and casing, with description of same.

Number the meter, switches, distributing boards, cut-outs, resistances, lamps and all fittings.

Where electricity is not supplied by a company, describe and allow provisional amount for the erection of a motor, dynamo, and accumulators.

Allow a provisional amount for perforations and making good.

PLASTERERS' WORK.

Internal and external work are measured in a similar manner.

The following items are measured at per yard superficial:—

Render Render and set Render, float, and set Rough cast	to brick walls.

Render in Portland cement to walls and floors; describe if jointed.

Lath, plaster, and set Lath, plaster, float, and set	to partitions and ceilings.

Colouring and whitening.

The following items are measured at per foot superficial:

Hearths, cornices, and mouldings over 12″ girt, and generally small work over 12″ girt, such as pilasters, &c. which the labour is more costly than ordinary work.

The following items are measured at per foot run:—

All work in narrow margins, cornices and mouldings under 12″ girt, angles, beads, enrichments, quirks, &c.

The following are numbered:—

Mitres, splays, stopped ends, extra labours, pateræ, modillions, caps to columns, trusses, centre ornaments, &c. in

All circular work to be kept separate.

The dimensions for ceilings with solid cornices are taken between the walls; to those with bracketed cornices, the measurements of ceilings are taken between the cornices. The lengths of cornices run *in situ* or bracketed, are taken as equal to the sum of the lengths of the walls minus two projections of the cornice; but if run on ground or rag and stick work, then take round of wall plus two projections for all external angles.

Memoranda.—One cubic yard of coarse stuff will require $\frac{1}{2}$ yard of chalk lime, 1 yard of sand, and 9 lbs. of hair.

This should cover in rendered work:—

36	superficial	yards	1″	thick
42	„	„	$\frac{7}{8}$″	„
48	„	„	$\frac{3}{4}$″	„
60	„	„	$\frac{5}{8}$″	„
72	„	„	$\frac{1}{2}$″	„
96	„	„	$\frac{3}{8}$″	„

but in the contraction and waste there will be a loss of from 12 to 15 per cent., therefore the quantities in the above table must be reduced by that amount to obtain the actual surface covered.

The pricking up coat for lath work will require about 10 per cent. more than that necessary for rendering.

GLAZIERS' WORK.

Glass is measured by the foot superficial, taking the extreme dimensions each way, and describing thickness as 15 oz., 21 oz., 26 oz., &c. in sheet glass, and the thicknesses in fractions of an inch in plate glass, and state whether patent plate, rough-cast plate, rolled plate, polished plate, or coloured glass, and describe method of fixing as sprigged back and front, puttied, beaded and screwed, and if bedded on wash-leather.

In shaped or circular panes, the circumscribing rectangle is measured, and an extra is charged for cutting to shape; a sketch of the shape should be given. Bent work is measured at per foot super, and charge for all necessary patterns. Lead lights are measured at per foot superficial, with a description and sketch of ornamental work.

PAINTERS' WORK.

Painters' work is measured by the yard superficial, and described as two, three, or four oils, according to the number of coats, and the area covered by the brush is the exact dimension to be paid for.

In measuring from executed work it is usual to allow for edges in height only, and returns in the width; in measuring from drawings, add to the surface dimensions for edges to plain work, ⅙th; to framed and moulded work, ¼th, to allow for edges.

Flatting should be described as "*extra to.*"

Staining, graining, sizing and varnishing are measured by the superficial yard.

The following items are measured at per foot run:—Skirting, handrail, gutters, rain-water pipes, iron bars, edges of shelves, strings, cornices, square balusters and newels.

Cutting-in should be described, and the item in which the labour occurs priced accordingly.

The following items are usually numbered:—Sash and door frames, each side measured as one, and if with mullions or transomes each division to be considered as a frame. They are taken as 10′ and under 25′; 25′ and under 50′. Sash squares, each side measured as one, by the dozen. They are taken as 1′; 1′ and under 2½′; 2½′ and under 5′; and above 5′. If sash has only one pane it is termed a sheet. Chimney pieces, door scrapers, ornamental balusters, and newels to staircases, iron air gratings.

French polishing on plain surfaces per foot superficial to surfaces covered by the polish.

Mouldings.—Girt and measure by the foot run; as in the example of a moulded spandril, framing panels would be measured over all before framing up, per foot super; styles, muntins, and rails are measured by the foot super; mouldings girt and measured by the foot run.

PAPERHANGERS' WORK.

The paper is charged at per piece, including hanging, and may be sized and varnished; if throughout, this may be included in description, if only in part measure separately.

To find the number of pieces required (allowing ⅐ for waste), divide the number of superficial feet in the space to be papered by 54; the result gives the number of pieces of paper required.

The superficial quantity may often be taken from the plasterers' bill.

A piece of paper is supposed to measure 36 feet long, $1\frac{3}{4}$ feet wide; this equals 63 superficial feet, but it is often found to measure 35 feet long, $1\frac{2}{3}$ feet wide. This equals $58\frac{1}{3}$ superficial feet.

GENERALLY.

The tendency of modern quantity surveying, in order to approach accuracy in estimating, is, 1st, to cube all the material and to pay in addition for the separate labours; 2nd, where this method is too tedious, the work is described and paid for by the superficies; again, 3rd, where the superficies is relatively small and the material has no fixed ratio to the cost of labour, the material and labour are fully described and paid for by the lineal dimension; again, 4th, where the labour is an unknown quantity or has a fancy value, then the detail is numbered, but it must be borne in mind that for similar work the accuracy obtained will be in the order respectively of the methods stated, though the time taken to obtain the answers will be in the reverse order, that is, the 1st method will prove the most accurate, but it will occupy the longest time.

Approximate Estimating. — Approximate estimates are obtained by finding the cubic dimensions of a building, measuring from the underside of the brick footings to halfway up the slope of the roof, adding any important projections and pricing at the cost this work may be judged to be worth. The success of this method will depend upon the experience and good judgment of the estimator.

Churches, chapels, &c. are often estimated per seat of the seating accommodation; hospitals, per bed; schools, per head of the number of scholars accommodated; and dwelling houses, per foot super of the floor area.

The cubing is the method usually adopted.

EXERCISES.

GRADUATED IN THE ORDER OF DIFFICULTY.

BRICKWORK.

No.	Page.	Question.	No.	Page.	Question.	No.	Page.	Question.
1	360	1	13	379	5	25	382c	14
2	364	1	14	372	5			
3	364	2	15	374	6			
4	372	1	16	374	9			
5	360	6	17	379	8			
6	368	5	18	380	10			
7	372	5	19	374	12			
8	376	1	20	366	12			
9	376	2	21	375	13			
10	376	3	22	380	13			
11	379	2	23	382	14			
12	379	3	24	382c	12			

MASONRY.

1	360	3	9	378	12			
2	368	1	10	380	9			
3	368	4	11	362	10			
4	376	3	12	374	12			
5	376	4	13	382c	10			
6	366	8						
7	370	8						
8	374	9						

GIRDERS.

1	360	4	5	374	7			
2	368	3						
3	370	7						
4	374	6						

JOINTS IN CARPENTRY.

1	360	2	6	364	5			
2	368	2	7	374	6			
3	368	3	8	376	6			
4	379	4						
5	360	5						

FLOORS.

1	368	3	7	380	11			
2	372	2	8	367	14			
3	362	7	9	378	14			
4	368	6	10	382c	12			
5	362	8						
6	374	8						

PARTITIONS.

No.	Page.	Question.	No.	Page.	Question.	No.	Page.	Question.
1	366	11						

WOOD ROOFS.

1	364	6	7	378	10			
2	376	7	8	362	12			
3	370	9	9	370	12			
4	370	10	10	382A	3			
5	374	10						
6	374	11						

IRON ROOFS.

1	366	9	5	363	14			
2	378	8						
3	371	14						
4	375	14						

JOINERY.

1	364	3	9	362	11	17	382A	5
2	364	4	10	366	11	18	382C	9
3	372	3	11	378	9			
4	366	7	12	378	11			
5	374	6	13	370	11			
6	379	7	14	371	13			
7	362	9	15	378	13			
8	379	8	16	382A	2			

PLUMBING.

1	360	3	5	380	12			
2	372	4	6	363	13			
3	366	7	7	382A	6			
4	376	5	8	382A	7			

SLATING.

1	379	6	3	374	10	5	363	13
2	379	1	4	378	10	6	382C	8

MISCELLANEOUS.

1	382A	1	3	382A	4	5	382C	13
2	382A	3	4	382C	11			

APPENDIX

SYLLABUS

OF THE

BOARD OF EDUCATION,

SOUTH KENSINGTON

(Formerly the Science and Art Department).

SUBJECT III.

BUILDING CONSTRUCTION.

(*Published August 1st*, 1903.)

A larger number of questions will be set in the examination papers than the candidate will be allowed to attempt, so that he may have some range of selection of questions which bear upon branches to which he has given special attention.

A student of this subject must be a draughtsman. He should be able to show definitely by drawings what he intends to have carried out, and he should be able, with readiness, to explain details of construction by drawings and sketches. In the several stages he will be expected to show proficiency both in finished drawing and what may be called descriptive and explanatory drawing. He should know the most usual methods of multiplying drawings and copies of quantities as practised in architects' and builders' offices. He should practise sketching approximately to scale, and paper ruled in faint squares is recommended for this purpose. It is to be noted, however, that the subject of examination is Building Construction, and not drawing in the abstract. Certain of the questions set will require written answers only; for others sketches to scale, on squared paper or otherwise, may suffice. The knowledge of drawing assumed includes the use of the usual drawing instruments, scales, various ways of laying down angles, applied projection (isometrical included), and perspective. In the 1903 examination and afterwards Students will be required to make an inked tracing of a portion of a drawing, the lines being very uniform and continuous, and fairly thick—such as would be useful for a blue print.

Questions may be put which will specially test the candidate's neatness and accuracy in inking in—curves and straight lines meeting curves, &c. The student is recommended to practise neat plain lettering and figuring.

Questions will also be set to test the candidate's knowledge of the tools, plant, and appliances used in building.

Tables will be supplied to candidates in Honours to assist them in calculation. Slide Rules may be used by candidates in all the stages.

Compulsory questions may be set at the examination.

MEMORANDUM UPON THE PREPARATION OF DRAWINGS BY STUDENTS.

Drawings to scale should be prepared in such a way as to give full information and exact guidance to the workmen who may have to use them, neither more nor less. All drawings, lettering, and numerals should be neat and clear; they should not be what is called "ornamental." Either italics or engrossing letters should be adopted.

There is no difference between the purpose of descriptive drawings for buildings and of those for machines and other constructive works, but there may be some difference in office practice in their preparation.

For good work architects should in descriptive drawings follow the modern method of machine draughtsmen. This is to produce an accurate, well-finished tracing from which any number of prints may be taken. "Blue prints" showing white lines on a blue ground are the most easily prepared, and serve most practical purposes. But prints on a white ground are specially suitable in some cases, as they can be coloured. Students should therefore in their classes make only pencil drawings on white paper.

Students of architectual construction need to practise freehand sketching. This they may do in connection with their work in class, which should largely consist of making dimensioned sketches and drawings from actual details of building construction. Little or no drawing from mere copies should be done.

STAGE I. (ELEMENTARY.)

The candidate should know: How a pull or a push of so many pounds may be represented in direction and magnitude by a straight line, and how three forces in one plane in equilibrium, at a point, may be represented to scale and are parallel and equal to the sides of a triangle; the weights of water and iron, and approximately of other materials used in building; the meaning of stress per square inch (or other unit of area); roughly the safe loads for common materials; about mortars, quality of good sand, Portland cement, limes; about slates and roofing tiles, and modes of fastening; about concreting in floors, roofs, walls, &c., plain floor tiling, spacing of joists, rafters, &c.; plain carpentry and joinery, trimming joists and rafters, usual scantlings of timber, proportions of doors, windows, floors, skirtings, simple trimmings round doors and windows; elementary ventilation and warming; bonds of brickwork; varieties of rubble masonry; plain plastering; plain painting and glazing; easy plumber's work; ironwork, locks, hinges, fastenings, grates, rainwater pipes and gutters, &c.; elementary drainage, connections with sewers and cesspools.

The bulk of the questions will have to do with elementary buildings—say labourers' cottages and artisans' dwellings.

Questions will be set to test the powers of direct observation of the student, and he is recommended to miss no opportunity he may have of inspecting buildings in process of construction.

STAGE II. (ADVANCED.)

The questions set in this stage shall be designed to test advanced knowledge of the subjects enumerated for the Elementary Stage. The bulk of the questions will apply to buildings up to and inclusive of town houses of £100 valuation, country villas, ordinary shops, and medium-sized warehouses.

The student should know: How to draw diagrams of stresses for roof trusses and simple braced girders with simple gravitation loads; how trusses of wood and of iron (or steel) are put together (spans up to 40 feet); the use of rolled joists, weights and strengths of stock sizes, the bearing of beams on walls; connection of woodwork to walls; to find the bending moment at any part of a beam under any system of gravitation loading (beam supported at both ends); what is meant by moment of inertia of a cross section; Young's modulus; combinations of iron (or steel) and Portland cement concrete, concrete roofs fireproof construction; to test Portland cement; varieties of timber, sources and characteristics; well-known building stones, bricks, and building materials generally; how to take rough quantities for estimating.

Questions will be set in: Excavation for foundations, sewers, &c.; timbering, piling, concreting, framing, nature of soil, &c.; damp courses; exclusion of vermin; dampness of site; connection of walls with ground, &c.; purpose made brickwork, terra-cotta, artificial stone, &c.; stone cutting, various dressings for quoins and ashlar, stone stairs, &c.; slating sizes and qualities of slate, hips, valleys, fancy slating, creasing, shelves, cisterns, sinks, &c.; advanced carpentry and joinery, panelling, stair building, &c.; asphalting, sound deadening, ventilation, hot-water supply, heating, gas and electric supply, water supply, lightning conductors, preservation of iron, timber, &c.; lead, &c.; lights in wood frames and in stone opes; various kinds of glass and glazing; ranges, grates, mantels, fastenings of all kinds; furniture of doors, &c., bells; painter's work of all kinds; advanced plumber's work, soil pipes, ventilation pipes, connections with sewers, traps, inspection chambers, water-closets, baths, sinks, flashings, flats, gutters, valleys, &c.; scaffolding; shoring and strutting; effects of wind and rain on buildings, &c., &c.

STAGE III. (or HONOURS, Part I.)

This Course will include buildings of all kinds and sizes. The student will be expected to show that he can practically apply principles of physics (mechanics, chemistry, &c.) in building construction. He should be able to design roof trusses and beams of every kind; to draw stress diagrams of trusses under every kind of loading; to calculate the thrust of arches and provide for every kind of stress at every part of large buildings; to understand the method of taking quantities, and he should know something of relative and approximate prices of work and materials; to explain in a rational way the mode of manufacture of important building materials—cement making, brick making, quarrying, &c.; he should be able to describe tests for every kind of important building material; he should be able to answer questions showing an intimate knowledge of all the matters enumerated for the lower grades.

HONOURS.

No candidate will be credited with a success in Honours who has not obtained a previous success in Stage III. (or Honours, Part I.).

This Course will include questions on the history of architecture. The candidate will be required to show by sketches and drawings that he has an accurate knowledge of notable examples of architecture. It will also include the subject of specifications.

The examiner will have in mind in setting the questions the actual practice of architects in designing buildings, and in their management of assistants and clerks of works to ensure that their orders will be properly carried out, the dealing with contractors, and also the actual carrying out of works under direct management. Candidates will be asked to make sketch designs and give instructions to draughtsmen for careful scale drawings and specifications. The questions may deal with any part of the subject and with any kind of building whatever.

Those candidates whose answering of the paper is sufficiently satisfactory will be summoned to South Kensington for a practical examination. This further examination will be held on one or more days—the time will not exceed seven hours each day. Candidates will be asked to design a building suitable for a definite purpose, and they shall be required to give such plans, elevations, and sections, and such details and notes for a specification, as shall be required by the examiner. An estimate of cost will also be required.

Candidates must provide T-squares, set squares, drawing instruments, ink, and colours. Drawing paper and drawing boards will be provided by the Board of Education.

No candidate can be classed in Honours who is not successful in the practical examination.

EXAMINATION PAPERS

OF THE

BOARD OF EDUCATION,

SECONDARY BRANCH,

SOUTH KENSINGTON, LONDON,

1902.

SUBJECT III.—BUILDING CONSTRUCTION.

GENERAL INSTRUCTIONS.

IF THE RULES ARE NOT ATTENDED TO, THE PAPER WILL BE CANCELLED.

Immediately before the Examination commences, the following

REGULATIONS *are* TO BE READ TO THE CANDIDATES.

Before commencing your work, you are required to fill up the numbered slip which is attached to the blank examination paper.

You may not have with you any books, notes, or scribbling paper.

You are not allowed to write or make any marks upon your paper of questions, or to take it away before the close of the examination.

You must not, under any circumstances whatever, speak to or communicate with one another, and no explanation of the subject of examination may be asked or given.

You must remain seated until your papers have been collected, and then quietly leave the examination room. None of you will be permitted to leave before the expiration of one hour from the commencement of the examination, and no one can be re-admitted after having once left the room.

Your papers, unless previously given up, will all be collected at 10 o'clock.

If any of you break any of these rules, or use any unfair means, you will be expelled, and your paper cancelled.

Before commencing your work, you must carefully read the following instructions :—

You are permitted to answer only seven questions.

Drawings must be made on the single sheet of drawing paper supplied, beginning on the side marked with your distinguishing number, which must face you at the right-hand top corner. *Sketches* may be made by hand on the squared paper attached to the drawing paper. Additional foolscap will, if necessary, be supplied to you by the Superintendent.

Answers in writing must be as short and clearly stated as possible, and the references to drawings and sketches must be made absolutely clear by letters or numbers.

The value attached to each question is shown in brackets after the question But a full and correct answer to an easy question will in all cases secure a larger number of marks than an incomplete or inexact answer to a more difficult one.

Questions marked (*) have accompanying diagrams.

The examination in this subject lasts for four hours

MAY, 1897.

FIRST STAGE OR ELEMENTARY EXAMINATION

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Plan of part of a brick wall at ground level, showing the footings and 9″ concrete foundations, the total depth below surface being 2′ 6″.

Draw, to a scale 1″ to a foot, a section through *a—a*, showing the joints of the brickwork by single lines. (11.)

*2. The head of an oak gatepost and the end of a rail which is to be housed, mortised, and fox-wedged into it.

Draw, to a scale of ¾″ to a foot, showing all the details of the joint before connecting up. The post to be shown in section. (11.)

3. Explain by sketches the meaning of the following terms:—

Joggle joint.
Spandrils of arches.
Lead plug.
Step flashing. (11.)

4. Draw, to a scale ⅓ full size, a rolled iron joist 10″ × 4½″, the web being ⅜″, and the flanges averaging ¾″. (11.)

*5. A joint in a timber tiebeam.

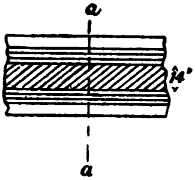
Draw to a scale of an inch to a foot, making any addition or alteration you think necessary to ensure a secure joint, and give the name of the joint.

Draw a similar joint, capable of resisting both direct tension and compression. (12.)

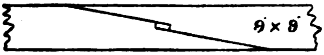
*6. Plans of two courses of brickwork at the angle of a building built in English bond.

Draw to a scale of ¾″ to a foot, showing the joints by single lines, and marking by thicker lines those portions of the joints which run unbroken down the wall. (12.)

(1.)



(5.)



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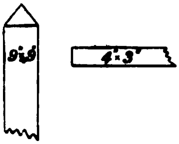

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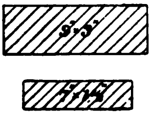

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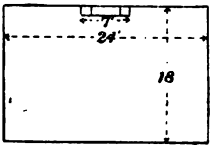

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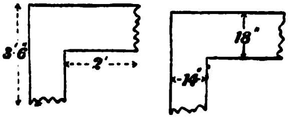

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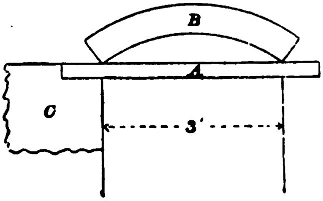

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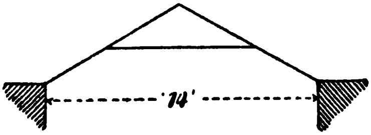

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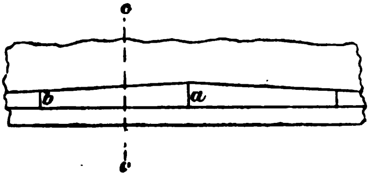

*7. Sections of the joists and boards of a common floor.

Draw, to a scale of 1½" to a foot, a cross section through three of the joists, showing the boards with a rebated and tongued heading joint.

Between one pair of joists show 2" × 1½" herring-bone struts, and between the other pair sound boarding and pugging. (12.)

*8. Plan of a room which is to have a double floor.

Draw to a scale of $\frac{1}{60}$, showing by single lines the arrangement of the different members of the floor, and writing their names against them.

Give a section, ¼ full size, through two of the floor battens, showing them laid with rebated and filleted joints. (13.)

9. Draw a horizontal section through the jamb of an external doorway in a store, showing a 14" brick wall, with bull-nose dressings outside, 5" × 4" solid frame, rebated and beaded, and the hanging stile of a 2¼" framed and braced door, including two rebated and beaded battens of same. (13.)

*10. Internal elevation of the head of a window opening in a stone building.

Draw to a scale of $\frac{1}{12}$, making any alteration you think necessary.

Give the names of the parts A and B, and at C show rough rubble built up to 20" courses. (14.)

11. Draw an elevation of a six-panel door 7′ × 3′, writing their names on the different parts, and showing the difference between panels square and flat, bead butt and bead flush, stating which is which. Also show by dotted lines how the parts are framed together. (14.)

*12. Line diagram of a timber roof with a rise of ⅓ the span, the rafters being 3½″ × 2½", and the collars 4½" × 2".

Draw, to a scale of ½" to a foot, a little more than half of same, showing how it would rest with overhanging eaves on a 9″ brick wall.

The joint between the collar and the rafter is to be shown in detail, and must be made so as not to weaken the rafter.

Give the name by which the roof is known. (15.)

*13. Plan of part of a lead roof gutter behind a brick parapet, showing the position of the joints in the lead.

Draw, to a scale ¼ full size, cross sections through *a* and *b*, giving full details of the joints. Also draw a section through *c*—*c*, including three courses of Countess slates on 1" boards. (15.)

14. Draw, to a scale of $\frac{1}{48}$, an elevation of a little more than half of an iron roof truss for a 30′ span, the rise being ¼ the span, from the following data:—

Principal tee-iron rafters 4″ × 3″ × ⅜″; three vertical rods of ¾″ and ½″ metal; four inclined angle-iron struts, 2′ × 2″ × ⅜″ and 2¼″ × 2¼″ × ⅜″.

Tie rod 1″ diameter, with a 9″ camber. (16.)

MAY, 1898.

FIRST STAGE OR ELEMENTARY EXAMINATION.

You are permitted to answer only *seven* questions.

*1. The figure shows a wrong way of laying bricks in English bond at the end of a 14″ wall.

Draw, to a scale of 1½″ to a foot, showing how the bricks ought to be laid, and mark the joints in the course below by dotted lines. (11.)

2. A door-opening in a 9″ internal wall of a brick building is 3′ 3″ wide.

Draw, to a scale of $\frac{1}{12}$, an elevation of the head of the opening, showing a 9″ × 3″ wood lintel and a common arch in two rings. (11.)

3. Give a vertical section, ⅛ full size, through the foot of a 6″ × 6″ wooden doorpost, fitted with a cast-iron shoe 4″ deep, of $\frac{3}{16}$″ metal, securely leaded down to a stone step. (11.)

4 Give, to a scale of ¾″ to a foot, a front elevation of an external framed and braced door, 3′ 3″ × 7′. Show 6″ margins, 4½″ battens, and indicate the unseen members of the framing by dotted lines. (11.)

5. Give explanatory drawings, ⅓ full size, in isometric projection or otherwise, showing an ordinary scarfed joint in a 4½″ × 3″ wall plate; also a dovetailed angle joint for same.

Do you consider the latter a good joint? If not, say why. (12.)

*6. One end of the tie-beam of a timber roof truss.

Draw to a scale of ⅛, adding the foot of the principal rafter, 5″ × 4″, framed to the tie-beam, and secured by a stirrup iron 2″ wide, with a connecting plate. (12.)

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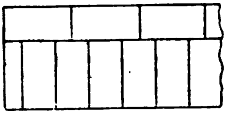

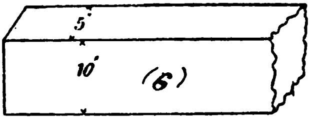

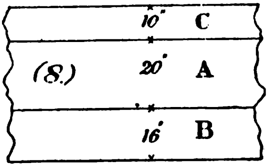

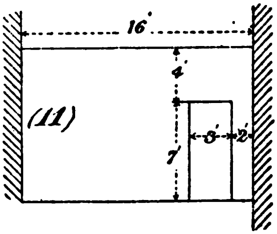

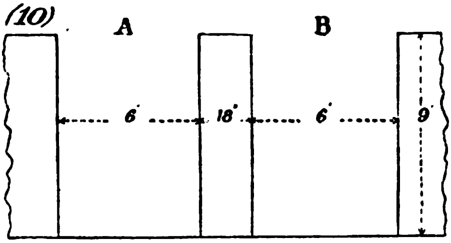

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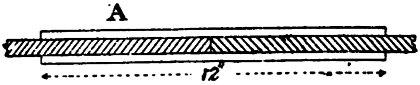

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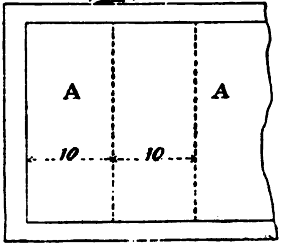

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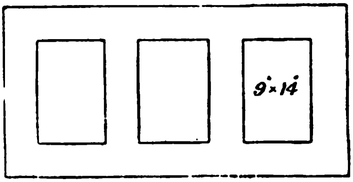

7. Give explanatory sketches, showing—

The difference between a "bossed-up" and a "dog-ear joint in lead work.

A torus moulded skirting.

A cocked bead and fillet. (12.)

*8. Elevation of part of a 16″ stone enclosure wall.

Draw, to a scale of $\frac{1}{18}$, showing, at *A*, random rubble, at *B*, coursed rubble, and, at *C*, a saddle-back stone coping with a 3″ roll.

Give a section of the coping. (13.)

*9. Longitudinal section of a riveted joint in an iron tie-bar, 9″ wide.

Draw, to a scale of ¼, a plan of the joint, showing nine ¾″ rivet holes, on the side *A*, arranged as chain riveting; and eight on the other side, arranged as zigzag riveting. (13.)

*10. Part elevation of two adjoining openings in a brick building with stone dressings.

Draw, to a scale of 3′ to an inch, adding a stone plinth 16″ high, weathered at top—an equilateral pointed arch over *A*—and a segmental arch of 120° over *B*.

Show stone voussoirs to both arches, 9″ deep, springing from stone imposts. (14.)

*11. Elevation of a common trussed partition carried on a brick wall below.

Draw half of same, to a scale of $\frac{1}{24}$, filling in the details, including the doorway.

The scantlings used to be 4½″ × 3″ and 4½″ × 2″, and the different members to be figured and named. (15.)

*12. Horizontal section through a brick chimney shaft.

Draw, to a scale of ¾″ to a foot, the end elevation of the top of the shaft down to two courses below the necking, which is to be three courses in depth, two plain and one weathered. Above the necking show eight plain courses; and then the cap, consisting of three sailing courses, four plain courses, and three splayed.

Mark in the horizontal joints of the brickwork throughout, and add the vertical joints also below the sailing courses. (15.)

13. Draw, to a scale of 3′ to an inch, a section of at least half of a timber roof over a 34-ft. span, with a pitch of 30° carried on 14″ brick walls, showing a truss in elevation, and taking the following details :—

Tie-beam 5″ × 10″—Principals 5″ × 5″—Queens 5″ × 3″—Straining beam 5″ × 7″—Straining sill 5″ × 3″—Purlins 8″ × 5″—Rafters 4″ × 2″—Ridge piece 9″ × 2″—1″ slate boarding.

Show all necessary ironwork to roof truss. (15.)

*14. Plan of part of a double floor, showing positions of girders by dotted lines.

Draw, to a scale of ¾″ to a foot, a section through *A A*, showing rolled iron girders 10″ × 5″, bridging joists 9″ × 2½″, floor battens 7″ × 1½″, and ceiling joists 5″ × 2″.

The depth of the floor to be kept down as much as possible. (15.)

APRIL, 1899.

ELEMENTARY STAGE.

INSTRUCTIONS.

You are permitted to answer only *seven* questions.

1. Draw, ¼ full size, a cross section through a saddle-back stone coping 12″ × 5″, throated and carrying an iron railing.

The section to be through the foot of a cast-iron standard 2″ diameter, showing it securely leaded to the coping. (11.)

*2. The feet of two timber posts framed into a sill piece.

Draw, to a scale of 1″ to a foot, a section through *a—a* showing the details of a mortised joint, and through *b—b* showing a bridle joint. (11.)

3. Explain, by means of sketches, the meaning of the following terms:—

Wood bressummer.
Tabled joint.
Pugging.
Trimmer arch. (11.)

*4. Elevation of a portion of a stone wall.

Draw, to a scale of 2′ to an inch, showing at *A* uncoursed squared or snecked rubble; and at *B*, squared rubble laid as coursed header work.

At *C* show plain block and start ashlar quoins. (11.)

5. Draw, to a scale of ¾″ to a foot, a cross-section of a trench 2′ 9″ deep, for the foundations of a building, showing 9″ of concrete carrying the footings of an 18″ brick wall built in English bond.

Fill in the joints of the brickwork up to the ground level. (12.)

*6. Section of a wooden floor binder.

Draw, to a scale of ⅛, adding a 6″ × 3″ bridging joist cogged to the binder, and a 4″ × 2″ ceiling joists tenoned to the same, and carrying a lath-and-plaster ceiling.

Show the joints in section. (12.)

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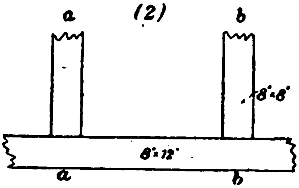

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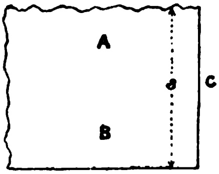

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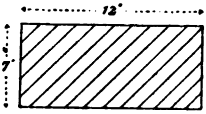

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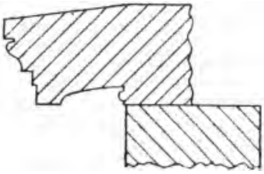

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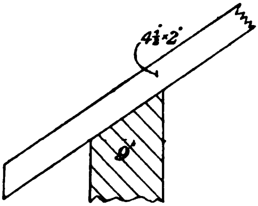

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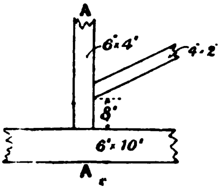

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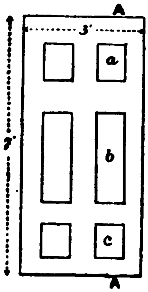

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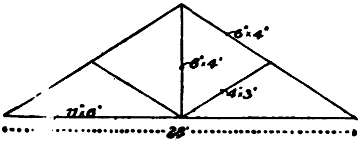

7. A cast-iron girder 15″ × 8″, and supported at both ends, has flanges of 12 and 4 square inches respectively.

Draw, ¼ full size, a cross section of the girder.

State why one flange is larger than the other. (12.)

*8. Section of a stone cornice on an 18″ wall built of coursed rubble.

Draw to twice the scale, adding a saddled joint in elevation and a blocking course 18″ high.

Give a cross section through the saddle joint, and state its object. (13.)

*9. Part of the eaves of a roof over a brick building.

Draw, to a scale of 1″ to a foot, adding a 4½″ × 3″ wall plate, a 7″ × 1″ fascia board, a 5″ ogee gutter, and 4 courses of slates, laid to a 3″ lap and centre nailed to ¾″ boards. Give the sizes and names of the slates shown. (13.)

*10. Elevation of the foot of a queen post in a timber roof truss.

Draw correctly, to a scale of 1″ to a foot, adding a stirrup iron 2¼″ × ⅜″, with jib and cotter adjustment.

Draw a vertical section through *A—A*, showing all the details of the iron and woodwork, before tightening up, including the framing of the queen post to tie-beam. (14.)

*11. Elevation of a 2″, 6-panel door, with 5″ and 10″ rails.

Draw, to a scale of $\frac{1}{12}$, a vertical cross section through *A—A*, making any alteration you think advisable, and showing the following details :—

At *a* a solid panel, bead flush on front, and bead butt at back.

At *b* a moulded and flat panel, chamfered at back.

At *c* a raised and moulded panel, square and flat at back. (15.)

*12. A line diagram of a timber roof truss, showing the scantlings of the different members.

Draw, to a scale of $\frac{1}{50}$, at least half of the truss, showing it resting on a 4½″ × 3″ wall plate and a 14″ brick wall.

Add a 4″ × 2″ common rafter properly supported.

Give the name of the truss, and of all the different timbers shown. (15.)

13. Draw a horizontal section, half full size, through one side of a window frame for double hung 1¾" moulded sashes. The section to include one style of the lower sash, showing how the glass is fixed, and the following details :—

⅝" inside and outside linings.
1¼" pulley piece.
⅜" back lining.
⅜" parting bead.
1" × ⅝" inside bead.
¼" parting slip. (15.)

14. Give line diagrams, to a scale of 6′ to an inch, of the following forms of iron roof trusses :—

(*a*) For a common trussed rafter roof, 24-ft. span.

(*b*) For a queen rod roof truss over a 36-ft. span.

In each case the rise to be ⅕ span, and the camber or tie-rod $\frac{1}{30}$ span.

In case (*b*) give an elevation, ¼ full size, of the joint at the foot of the king-rod, which is to pass through the tie-rod with a screw-nut adjustment ; the different members being of 1¼" and 1" round iron, and tee iron 2½" × 2" × ⅜". (15.)

MAY, 1900.

ELEMENTARY STAGE

INSTRUCTIONS

You are permitted to answer only *seven* questions.

1. Briefly define ordinary English brick bond.

Draw, to a scale of ¾″ to a foot, a plan showing the arrangement of the bricks in a 2½ brick wall built in English bond, the bricks in the course below being indicated by dotted lines. (11.)

*2. Section of part of a common floor, showing 9″ × 3″ joists, and 1½″ boarding with a heading joint.

Draw, to a scale of ⅛, making any alteration you think necessary, and adding pugging and a lath-and-plaster ceiling.

State the object of pugging, and give the name of the heading joint. (11.)

*3 Interior elevation of a 7′ × 3′ door.

Draw to a scale of ¾″ to a foot, making any alteration you think necessary.

Write against the door its name, and the names of all its different members. The joints need not be shown. (11.)

4. Draw one-half full size a section of an ordinary 2″ lead roll, and of a hollow roll, as used for lead flats. (11.)

*5. Plans of two successive courses of brickwork at the junction of a party wall with the main wall of a building, the latter being built in single Flemish bond.

Draw, to a scale of ¾″ to a foot, showing the joints of the brickwork. (12.)

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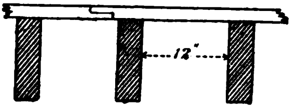

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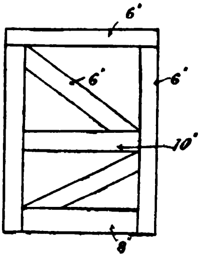

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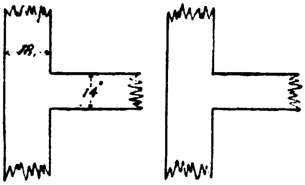

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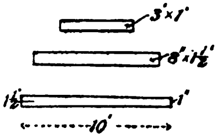

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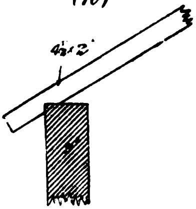

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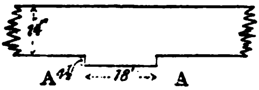

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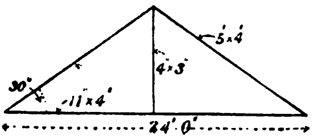

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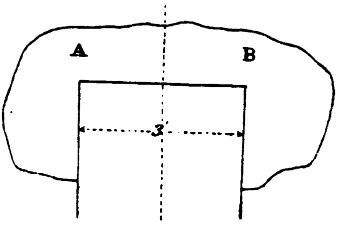

6. Give sketches explanatory of the following terms :—

Flitch girder.
Tusk tenon.
Squint quoin.
Transom. (12.)

*7. Sections showing the different members of a cast-iron cantilever.

Draw the section of the cantilever, $\frac{1}{8}$ full size. (12.)

8. Show clearly by sketches the difference between a double floor with rebated and filleted battens, and a framed floor with ploughed and tongued boards. (14.)

*9. Horizontal section through part of a brick boundary wall built in English bond.

Draw to a scale of 1½ inches to a foot, showing the joints of the bricks in English bond in two courses, the lower one by dotted lines ; also an elevation of the face *A*, showing the four top courses of the wall, finished with a stone saddle-back coping 6″ deep, 3″ wider than the wall, and weathered down 3″.

Add a cross-section of the coping over the 14″ brickwork, showing it properly treated so as to throw rain clear of the face of the wall. (14.)

*10. Section of part of a small span roof.

Draw to a scale of 1″ to a foot, adding Countess slates with 4″ lap, centre nailed on 2″ × ¾″ battens, a 3¼″ half-round eaves gutter, and a 1″ beaded fascia board. The rafter to project 9″ from face of wall. Pitch of roof 30°.

Make any other addition or alteration you think necessary. Name the different parts. (14.)

*11. Line diagram of an ordinary timber truss for a 24-ft. span.

Draw at least half the truss, to a scale of $\frac{1}{24}$, making any addition you think necessary.

Give the name of the truss, and enlarged drawings, to a scale of 1½″ to a foot, of the joints at the head and foot of the principal rafter. (14.)

12. Draw to a scale of 1½″ to a foot, the plan and central cross-section of an 11″ × 6″ stone window sill for a 3′ 6″ opening. The sill to be weathered, throated, and grooved, and to project 2½″ from a 14″ brick wall.

At right end of plan, show the course of brickwork, in English bond, immediately above the sill, with a 4½″ reveal; and at left end the brick work upon which the sill rests.

(14.)

*13. External elevation of a window head in a 14″ brick wall finished externally with a 14″ gauged camber arch, and internally with a 9″ × 3″ wood lintel and common arch.

Draw to scale of 1½″ to a foot, showing at *A* the details of the external elevation, and at *B* the internal elevation, the brickwork being in single Flemish bond. (15.)

14. Draw to a scale of $\frac{1}{24}$, a little more than half of an iron king-rod roof over a 28-ft. span. Rise ¼ span. Show:—

Principal rafters and struts, of tee iron.

King and tie rods, of round iron.

Common rafters and their supports, of wood.

The scantlings and joints can be assumed. (15.)

MAY, 1901.

ELEMENTARY STAGE.

INSTRUCTIONS.

You are permitted to answer only *seven* questions.

1. Why is a brick made so that its breadth is less than half its length? Can you explain any advantage in "perforating" bricks? What are gauged arches? (12.)

2. Draw, to the scale of $\frac{1}{16}$, the plans of two courses of a brick pillar in English bond; the pillar to be square in section, four bricks in the side. To what height could you safely build a pillar of this section, assuming the safe load on a course of bricks to be 8 tons per square foot and taking the weight of a cubic foot of brickwork at 120 lbs.—neglecting wind pressure? (12.)

3. What are:—a skew arch; a skewback; a pillar; an abutment; a column; weathering of a window sill; weathering of stone; voussoirs; chamfer; plinth? (12.)

*4 A rubble wall with half-round concrete coping; draw it to the scale of $\frac{1}{16}$. Showing the stones and mortar. (12.)

5. Show three soakers with cover flashing in position against a brick wall—slates 24″ long. Show clearly to the scale of $\frac{1}{4}$ all details, with such drawings and sketches, accompanied by explanations and dimensions, as you think sufficient. (12.)

6. Draw or sketch, to the scale of $\frac{1}{4}$:—
   (1.) A tenon and housed joint, mortised piece 4″ × 4″, tenoned piece 3″ × 4″.
   (2.) A tusk-tenoned joint, 9″ × 3″ timbers.
   (3.) A dovetailed notch, timbers 4½″ × 3″. (12.)

7. Draw or sketch, to the scale of $\frac{1}{8}$, the top and bottom of a king-post showing attachments of principal rafters and of the struts and tie-beam, and showing ironwork:—rafters 8″ × 4″, shank of king post 6″ × 4″, struts 4″ × 4″, tie-beam 12″ × 4″. (12.)

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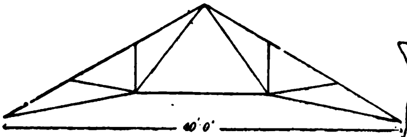

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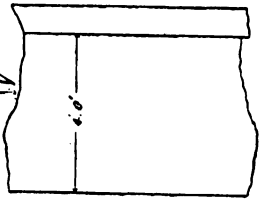

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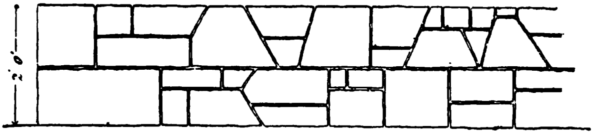

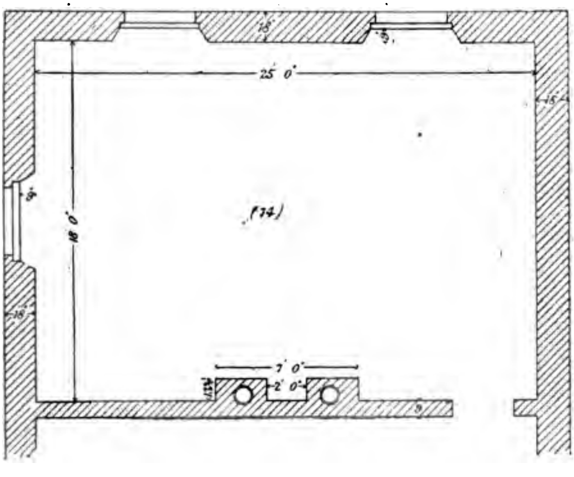

(14)

*8. A skeleton drawing of an iron roof truss. The rafters are formed of L irons. Draw, to the scale of $\frac{1}{2}$, the joint at the apex. Repeat the diagram on your paper, and putting reference numbers to the different members, sketch cross-sections of them. (14.)

9. Draw or sketch, to the scale of $\frac{1}{4}$, a cross-section showing bottom rail of sash, wood sill of window frame, stone sill, and window back; showing elbow. The window back is 2 feet high and the wall of the recess is 10 inches thick. (14.)

10. Draw or sketch, to the scale of $\frac{1}{8}$, cross-section of eave extending 4 feet up the roof showing slates resting over a cut stone eave course: the wall is 18″ thick, rafters 5″ deep, without roof trusses,—ceiling joists at wall plates; slates 20″ long. Explain fully. (14.)

11. Draw, to the scale of $\frac{1}{16}$, the inside elevation of a ledged and braced door, and door frame; the door is 7′ × 3′. Show hinges, latch, stock lock; sketch cross-section showing jambs (wall $1\frac{1}{2}$ bricks thick). (14.)

*12. Two courses of masonry: how would you describe it? Sketch these two courses on your paper, and put reference numbers on the stones of the top course showing the order in which you think a mason would set them, giving reasons. (14.)

13. Draw, to the scale of $\frac{1}{8}$, elevation of a double casement or French window 6′ × 3′ 6″: draw cross-section of bottom bar of window and sill of frame; sketch hinges and fastening bolt. What is this kind of bolt called? (15.)

*14. A floor, of fir timber, joists lathed and plastered below to form ceiling of lower room. Draw plan, to the scale of $\frac{1}{48}$, showing by single lines complete joisting, figure scantlings. Draw, to the scale of $\frac{1}{8}$, cross-section through hearth reaching above camber-bar of fireplace. Show details of bearing of joists and of trimmer. (15.)

MAY, 1902.

ELEMENTARY STAGE.

INSTRUCTIONS.

You are permitted to answer only *seven* questions.

*1. Sketch this tool upon your paper, showing the pick better placed, and explain why you alter it. For what is this tool used? (12.)

2. What are:—Reveals, Jambs, Collar braces (Collar beams), Battens, Studs, Deals, Planks, Perpends, Screeds, King-closer? (12.)

*3. The figure shows in skeleton a bracket used by builders for pointing brickwork or for outside plastering: sketch the bracket so that an exact drawing could be made from your sketch (marking dimensions). Show clearly how its parts are connected (the parts being of red deal); show how it is supported when hung against a wall. (12.)

*4. What is the name of the bracket of the previous question? If we assume that it carries a uniformly distributed load of 8 cwt. on *AB*, so that we may imagine a downward force of 4 cwt. at *A*, what kind of stress is in *AC*, and what is its amount? (12.)

5. Given sand, lime, and hair, as delivered at the building, describe in detail how you would prepare "*coarse stuff*" for plastering—you are not supposed to have a mortar mill. (12.)

6. Sketch neatly to the scale of about $\frac{1}{8}$ a slate of the dimensions 24″ × 12″ dressed and holed: the lap is 4″. What are the dimensions of the "weather" (or margin) of this slate? What is the distance from the hole to the tail? (12.)

*7. What is the name of the lock shown? Describe how you would fix it to a door. Explain and illustrate by sketches the mechanism of a common single tumbler lock. What are the "*wards*"? (12.)

*8. The sketch shows a door frame for an outside door: it is set upon door-blocks and the brick walls are being built to it.

Draw carefully to the scale of $\frac{1}{12}$ an elevation of the door frame, step, sill, and brickwork (showing the joints by double lines to the left of the door for, say, three bricks from the door): show temporary bracing: describe how you would stay the door frame temporarily. Draw, to the scale of $\frac{1}{4}$, cross-section of frame at *AB*, showing the plan of top course of brickwork, and a short piece of vertical section at *C*, showing the connexion with the door block. (14.)

9. Sketch to the scale of $\frac{1}{12}$ a sample of snecked rubble masonry face (say about 4′ by 4′). Show the mortar joints with double lines.

   Sketch also the top of the sample, as a plan, showing how you bond the wall across. (14.)

10. A brick wall, 21′ high (measured from the soil on which it rests) 13$\frac{3}{4}$″ thick, carries a load of 1 ton per foot run on its top. Say what is the approximate weight of a cubic foot of brickwork. Draw, to the scale of $\frac{1}{24}$, a cross-section of the footings on the assumption that the soil is not to be stressed to a greater amount than 1 ton per square foot. (14.)

11. Describe exactly the laying of batten width tongued and grooved common Baltic flooring; how would you manage when the floor has been finished so far that there is no longer room for the cramps between the wall and finished floor? Sketch the usual flooring nail. What is it called? Where do you drive the nails? Sketch a cross-section of a heading joint. (14.)

*12. For what purpose is this tool used? You have to cover a right circular cone with 6 lbs. lead. The cone is 3′ in diameter at the base, and it is 2′ high. Assuming that the joints are butted, what is the weight of the lead? Such a cover being made, if a straight cut is made from the apex to the circumference of the base, the cover may be made to lie flat; draw to the scale of $\frac{1}{12}$ its outline when thus flattened. (14.)

13. What is bond in brickwork? When you say that a certain wall is built in Flemish bond, to what do you refer? You

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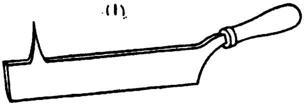

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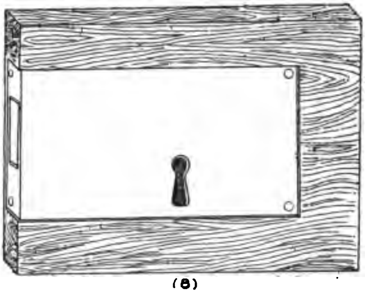

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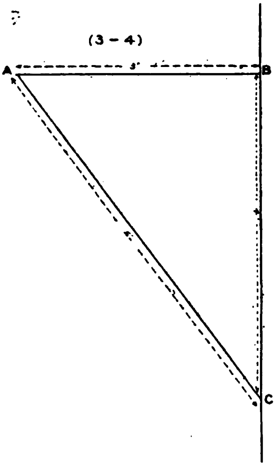

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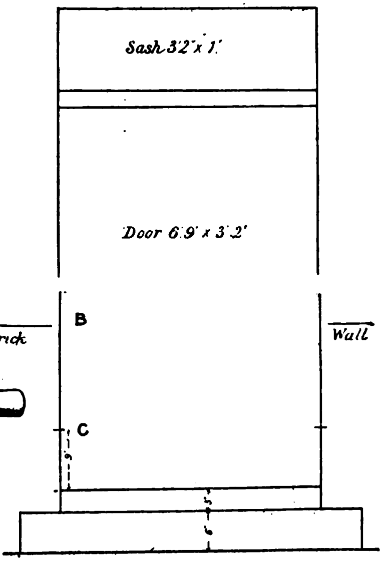

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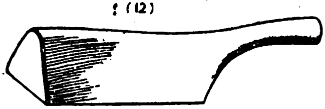


have to build a 1½ brick wall, showing Flemish bond in *one face*—the appearance of the other face is of no consequence as it is to be plastered. *No bats are allowed.* Sketch the plan of a course, say 5 bricks long, in full lines and show the joints of the course below in dotted lines. (15.)

14. Describe carefully the work of laying a kitchen floor with 6″ × 6″ tiles, ½″ thick, in two colours. The floor is 14′ × 13′ : how many tiles ought to be *ordered* for the work? (15.)

May, 1903.

ELEMENTARY STAGE.

You are permitted to answer only *seven* questions.

For what work is this tool used? Describe how the workman holds it when he uses it for ordinary work. (12.)

2. What are:—meeting-rail, muntin, tread, riser, going, lacing course, quirked ogee, coarse stuff, gauged stuff, droved work, rusticated? (Full marks will be given for *nine* correct definitions.) (12.)

*3. In a certain town electric wires are borne on brackets, like that shown: given the weight at *A* as being 40 lbs., assuming that this pressure may be transferred to the point *B* where the bracket bears against the slate, as shown, and assuming that the directions of the reaction and of the third force are as shown; what is the amount of the reaction in lbs.? (15.)

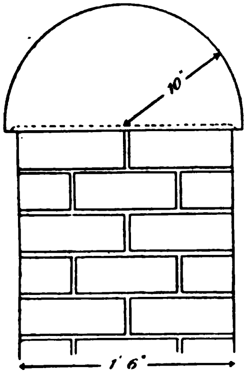
*4. Make a tracing, in ink, of this drawing and of the writing and figures. (The Indian ink should be sufficiently thick to give opaque lines, suitable for photographic printing; the lines should be well defined, uniform in breadth, having firm unbroken edges; and they should neither stop short of nor go beyond the proper points.) (15.)

5. Sketch (approximately) to the scale of $\frac{1}{2}$, a good strong thumb latch for a door; also the keeper, or catch, to be fastened to the door frame. Describe what you consider to be important points in a good latch, such as you sketch. (12.)

6. (*a.*) What is a bib-cock? (*b.*) Describe how a "wiped-joint" is made. (12.)

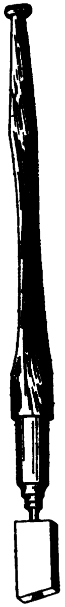
7. A rectangular rain-water tank weighs 300 lbs., it is 6′ × 4′ and it is 2′ 6″ deep (internal dimensions), it is supported with its bottom horizontal. Owing to a stoppage of the overflow pipe, it is filled with water. (*a*) What is the

(4)



Elevation.

(1.)



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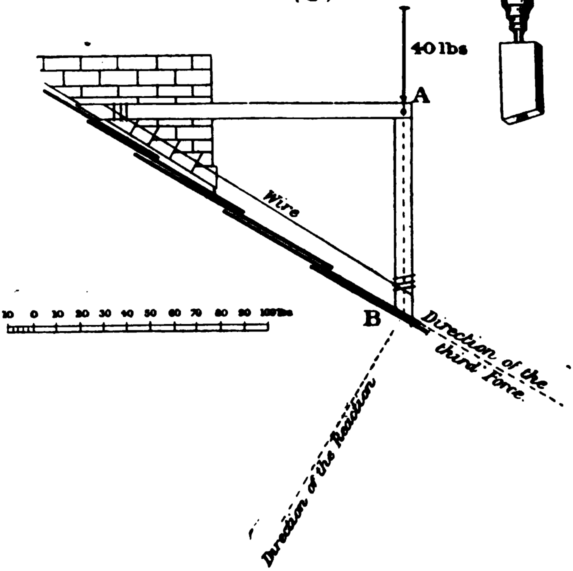
40 lbs
A
Wire
B
Direction of the third Force.
Direction of the Reaction
10 0 10 20 30 40 50 60 70 80 90 100 lbs

pressure of the water, per square foot, on the bottom of the tank? (*b.*) What is the weight of the tank and water? (*c*) How many gallons of water does the tank contain? (14.)

8. The slates on a roof are 24″ × 12″, an average slate weighs 7 lbs., the slates are laid with a lap of 4 inches; what is the weight of slates which covers an average square of roof? (14.)

9. Draw, to the scale of $\frac{1}{12}$, the elevation of a casement window (not a *pivoted* sash) 4′ × 2′ 6″ (sash size); a single sash in 4 panes; show reveals and stone sill; sketch, approximately to the scale of $\frac{1}{4}$, the essential details of the hinges and fastener. (14.)

10. Sketch, to the scale of $\frac{1}{12}$, the face (elevation) of a completed course of rubble masonry (the course being, say, 15″ deep); sketch on top of this completed course portions of a second course in process of building; explain why the stones shown—of the second course—are placed where you sketch them. How does the mason keep his work truly in line? How does he use his plumb rule in rock-faced work? (14.)

11. A plasterer is laying on the first coat of coarse stuff on lathed work, and you see him driving the trowel at right angles to the direction of the laths. This is wrong; can you explain why it is wrong? (12.)

12. Sketch to the scale of $\frac{1}{8}$ (approximately) a fireplace—grate, oven, and boiler—suitable for the kitchen or living-room of an artizan's cottage; explain the setting and flues. (14.)

13. Describe how you would prepare (from materials in the usual commercial conditions) a pot of light-coloured paint for fourth coating, inside work; give a name to the shade of colour you produce. (12.)

14. Draw plans of two successive courses of a half-brick built chimney stack of three flues (scale $\frac{1}{12}$); show mortar joints as double lines, show pargetting. (12.)

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